This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

UC-NRLF
$B 116 826

[illegible] ૨૭ [illegible]

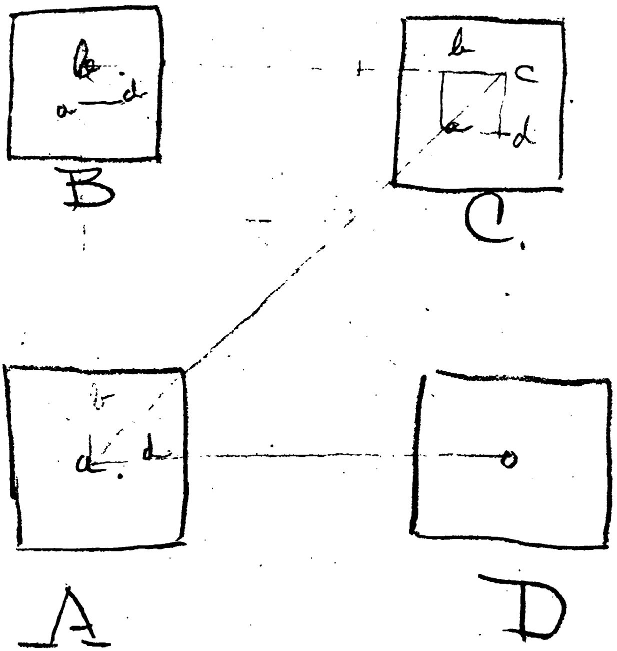
LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA.

Frank W. Maher

Berkeley

Cal.

College of Engineering



four methods plane surveying

1° radiation set up any part of the field not very exact necessary to measure every distance from the table.

2° progression set up at every station and measure every line in the boundary of the field interior filled up by radiation or by intersections

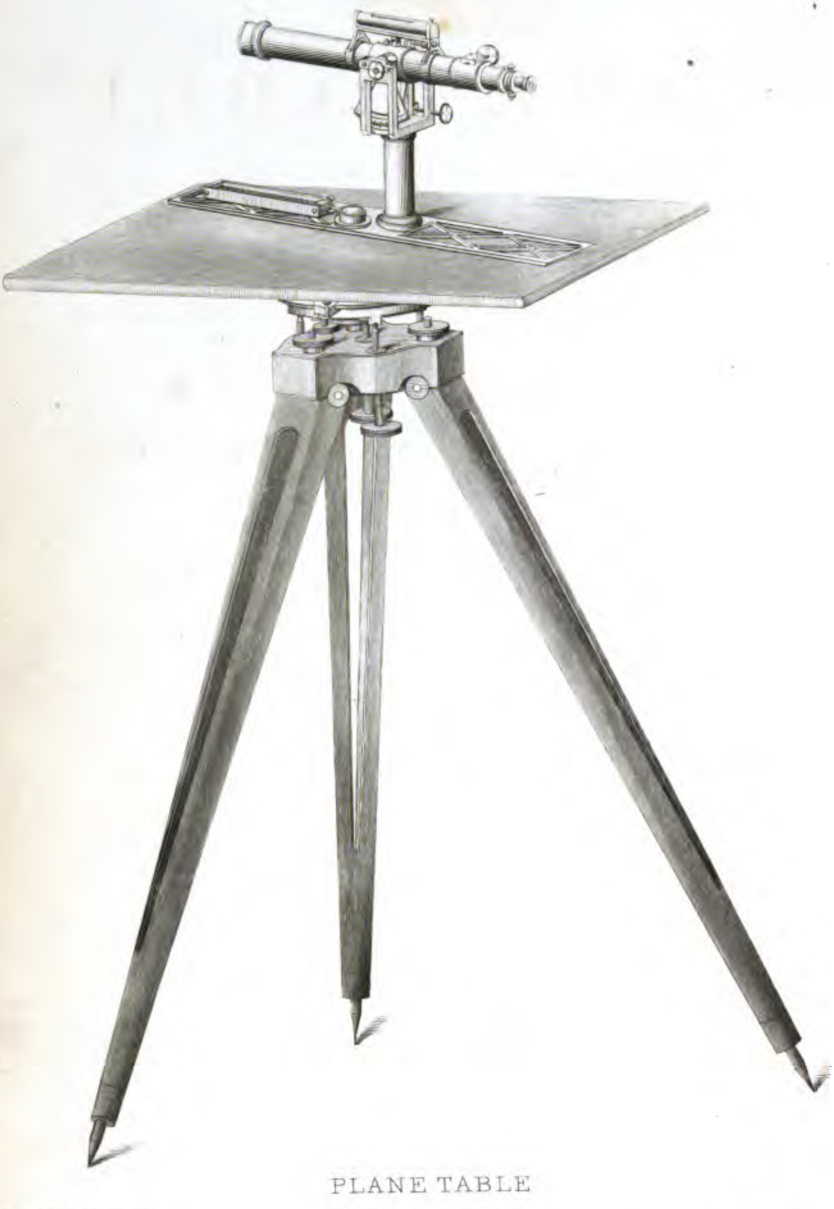
3° Prosection measure base line or part of one of the sides occupying each end and sight to every station same as in triangular surveying

4° resection requires the measurement of one line.
Set up at A sight to D and measure ad and plot d. draw line ab and remove to B and orient place and across d and sight to D, and the intersection gives b (this is called resection on D) remove to C and orient sight to A and the intersection gives c or sighting to D remove c. c is determined by 2 intersections

This is rather [illegible]

Due 27 Feb.

LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA.



PLANE TABLE

U.S.Coast Survey

PLANE-TABLE

Prof W. [illegible]

AND ITS USE IN

TOPOGRAPHICAL SURVEYING.

FROM THE PAPERS OF THE

UNITED STATES COAST SURVEY.

NEW YORK:
D. VAN NOSTRAND, PUBLISHER,
23 MURRAY STREET AND 27 WARREN STREET.
1869.

[illegible]
and
Carrie [illegible]
Gilmore

U.S. Coast and Geodetic Survey.

PLANE-TABLE

Frank W. Maher

AND ITS USE IN Jany 11th 1877

TOPOGRAPHICAL SURVEYING.

LIBRARY OF THE UNIVERSITY CALIFORNIA

FROM THE PAPERS OF THE
UNITED STATES COAST SURVEY.

NEW YORK:
D. VAN NOSTRAND, PUBLISHER,
23 MURRAY STREET AND 27 WARREN STREET.
1869.

TA571
.15

Entered according to Act of Congress, in the year 1869, by

D. VAN NOSTRAND,

in the Clerk's Office of the District Court of the United States for the Southern District
of New York.

27430

LIBRARY
OF THE
UNIVERSITY
OF
CALIFORNIA.

THE PLANE-TABLE

AND ITS USE IN

TOPOGRAPHICAL SURVEYING.

THE following description of the plane-table, and notes upon its use, in the shape in which it is at present employed upon the Coast Survey, are given as the results of a long experience of its good qualities on that work. Being the instrument best adapted to topographical purposes, it is desired to supply information not to be found in the very inadequate notices given of it in most American and English works, and to furnish topographical surveyors with a practical manual of its use. This paper may seem, in some cases, somewhat amplified, but those more familiar with the instrument will overlook details intended for the benefit of beginners.

The invention of the plane-table is ascribed to Prætorius in 1537, but the first published description appears to be that of Leonhard Zubler, in 1625, who ascribes the "beginning" of the instrument to one Eberhart, a stonemason. From this time forward it has received successive improvements, chiefly from the Germans and French, until it has reached its present form, which seems to be in keeping with the existing state of science.

DESCRIPTION.—Topography is a more or less detailed representation, in the form of a map, of a certain area of ground, on a specified scale or proportion of nature, mechanically constructed by the measurement of angles, direct linear measurement, and tangential lines. In plane-table practice these are drawn in pencil upon the paper, which is spread upon the table, and the details are filled in according to established conventional signs. The work is so conducted that the required figure is obtained in the field at once by the simultaneous measurement and plotting of the angles; and while it is done with as much accuracy as it could be plotted with a protractor, errors of transfer are avoided and much time saved.

The plane-table at present in use by the Coast Survey (see Plate No. 1) is composed of a well-seasoned drawing board, with bevelled or rounded edges about thirty inches in length, twenty-four in width, and three-quarters of an inch thick. It is commonly made of several pieces of white pine, tongued and grooved together, with the grain running in different directions to prevent warping. It is supported upon three strong brass arms, to which it is fastened by screws passing through them and entering the under side of the board, the three holes for the reception of the screws being guarded by brass bushings let into the wood, and situated equidistant from each other and from the centre of the table. By means of these screws the board can be removed at will. The arms rest upon the sloping upper face of a conical plate of brass, to which they are permanently fixed. Upon its lower edge or periphery this cone is fashioned into a horizontally projecting rim, the inferior face of which is as nearly as possible a perfect plane, and this in its turn rests upon a corresponding rim of a somewhat greater diameter, projecting slightly beyond it. This second rim forms the upper and outer flange of a circular metal disk in the form of a very shallow cylinder. The inferior face or plane of the upper flange or rim has, at its contact with the superior face of the lower, a horizontal rotatory movement about a common centre, which is the centre also of the instrument, and the two are held together by means of a solid conical axis of brass extending upwards from the centre of the inner face of the lower disk. A socket of similar shape fits exactly over this axis, projecting downward from the inner side of the apex of the conical or upper disk. The two plates are held together by means of a mill-headed screw capping the cone from the outside, and which can be loosened or removed at pleasure.

A clamp fastened to the edge of the upper rim permits, when loose, the revolution of the table about its centre, and, when clamped to the lower limb, holds the table firm, while a tangent screw gives a more delicate movement.

Three equidistant vertical projections of brass grooved on the under side, and cast in one piece with the under face of the lower disk, extending from the periphery towards the centre, rest upon the points of three large screws which come through a heavy wooden block below. This block, which is the top of the stand and is approximate in form to an equilateral triangle, is made of three pieces or horizontal layers, and is two and-a-quarter inches thick and very strong.

The three screws last mentioned have large milled heads, are quite stout, and play through the block from below by means of brass female screws let into it. They are the levelling screws of the instrument, and are equidistant from its centre.

Upon the under side and centre of the lower metal disk is a socket containing a ball with a brass arm, which projects through the centre of the block from beneath. The lower end of the arm is threaded, and upon it plays a female screw with a large milled head, which can be relaxed or tightened at pleasure. This screw clamps the whole upper part of the instrument to the stand; it is loosened only before levelling, and kept securely clamped at all other times.

The block is supported upon three legs, and with them forms the tripod or stand of the instrument, the legs being of such a length as to bring the table to a convenient height for working, and so arranged as to be taken off at will, or closed so that their iron-shod and pointed ends can be brought together or moved outward, as may be required. For lightness the legs are generally made open through the middle of their length, though sometimes they are solid, and each one is fashioned at the top into a cylindrical form with an outer flange, the cylinder fitting into a groove on the under side and near the edge of a truncated vertex of the block. The flange, by coming in contact with the lower edge of the block, prevents a too great spread of the legs. A brass screw, connected at right angles with the middle of a movable bolt which runs through the axis of the cylindrical head of the leg, and projecting through a hole in the block, is fastened above by a female screw with a large milled head.

A pair of compass sights or a watch telescope has sometimes been attached to the under side of the board of the plane-table. When the table has been put "in position," the watch telescope is directed to some well-defined object, and by after reference to it any movement which may have taken place, out of position, in the table during its use, can be detected and adjusted. This, however, is but a complication of the instrument, and the same purpose can be more readily served by the alidade itself. The watch telescope has not been used in Coast Survey work.

Rollers have been attached to the under side of the table, taking the place of clamps for holding the map in its place; but these are very liable to get out of order, and are not regarded with favor by the best topographers.

The alidade consists of a brass rule about twenty-two inches long, having a circular level on its upper face. Near the middle of the rule is a perpendicular cylindrical column of brass, called the "standard," surmounted by two square brass plates joined by screws, and supporting horizontally a conical journal, through which extends a closely fitting cone of brass, coming from and attached to the side of the telescope. This cone forms the axis of the vertical movement of the telescope, and is secured at the extremity by a screw which holds it in its place. The telescope itself has the usual cross-hairs and means of focal adjustment.

A transverse level is fastened to the edge of the upper of the two plates at the top of the standard by means of adjusting screws.

The telescope is so placed that its line of collimation is above and in the same vertical plane with the fiducial edge of the rule, though this is not absolutely necessary. Its position with regard to the edge, and its relation to it, should, however, be constant.

A vertical arc with a tangent screw and clamp is attached to the telescopic side of the lower brass plate, and, with a vernier which moves in arc as the telescope is raised or depressed, is used in the measurement of vertical angles for heights.

A small strip of brass is sometimes attached by means of horizontal hinges to the edge of the rule, after the manner of the ordinary parallel rule, for the purpose of enabling the topographer to draw a more extended line upon his sheet than the limits of the rule would permit; but, as it is liable to the same objection as that instrument, it has not come into general use.

A *declinatoire*, consisting of a rectangular metal box containing a needle, so arranged that when pointing north it is parallel to the outer straight-edge of the box; a scale of equal parts of brass or German silver; a set of metal clamps for fastening the map to the table; a pair of sharp dividers; India-rubber, pencils, and a penknife, complete the list of essentials for prosecuting plane-table work.

Since writing the foregoing description of the alidade, it has been somewhat modified and improved. (See frontispiece.) The telescope, instead of being supported on the side of the standard, is "transit mounted," resting upon an axis which is supported at either end upon a cross-piece of brass, upheld by two square columns, having their bases upon a square plate forming the top of the standard, the support and standard being firmly united. This arrangement brings the centre of gravity over and coincident with that of the standard, instead of outside of it, as heretofore.

The vertical arc is better protected by being placed inside of the two square uprights, and the tangent screw made more stable by being made to play through one of the uprights on the opposite side from the arc.

An arrangement for attaching a riding level to the telescope, and the declinatoire being permanently fastened to the rule, are also improvements upon the old pattern.

ADJUSTMENTS.—From the nature of the service, in some sections of the country the plane-table is often necessarily subjected to rough usage, and there is a constant liability to a disturbance of the adjustments; still, in careful hands, a well-made instrument may be used under unfavorable conditions for a long time without being perceptibly affected. One should not fail, however, to make occasional examinations, and, while at work, if any difficulty be met with, which cannot otherwise be accounted for, it should lead directly to a scrutiny of the adjustments.

1. *The Fiducial Edge of the Rule.*—This should be a true straight-edge. Place the rule upon a smooth surface and draw a line along its edge, marking also the lines at the ends of the rule. Reverse the rule, and place the opposite ends upon the marked points, and again draw the line. If the two lines coincide, no adjustment is necessary; if not, the edge must be made true.

There is one deviation from a straight line, which, by a very rare possibility, the edge of the ruler might assume, and yet not be shown by the above test; it is when a part is convex, and a part similarly situated at the other end concave, in exactly the same degree and proportion. In this case, on reversal, a line drawn along the edge of the rule would be coincident with the other, though not a true right line; this can only be tested by an exact straight-edge.

2. *The Level attached to the Rule.*—Place the instrument in the middle of the table, and bring the bubble to the centre by means of the levelling screws of the table; draw lines along the edge and ends of the rule upon the board to show its exact position, then reverse 180°. If the bubble remain central, it is in adjustment; if not, correct it one-half by means of the levelling screws of the table, and the other half by the adjusting screws

attached to the level. This should be repeated until the bubble keeps its central position, whichever way the rule may be placed upon the table. This presupposes the plane of the board to be true. If two levels are on the rule they are examined and adjusted in a like manner.

Great care should be exercised in manipulation, lest the table be disturbed.

3. *Parallax.*—Move the eye-glass until the cross-hairs are perfectly distinct, and then direct the telescope to some distant, well-defined object. If the contact remain perfect when the position of the eye is changed in any way, there is no parallax; but if it does not, then the focus of the object-glass must be changed until there is no displacement of the contact. When this is the case, the cross-hairs are in the common focus of the object and eye-glasses.

It may occur that the true focus of the cross-hairs is not obtained at first, in which case a readjustment is necessary, in order to see both them and the object with equal distinctness and without parallax.

4. *To make the Line of Collimation Perpendicular to the Axis of Revolution of the Telescope and the Axis of Revolution Parallel to the Plane of the Rule.*—The instrument is set up and carefully levelled, and the cross-hairs directed to a plumb or other vertical line. If the cross-hairs cover the line when the telescope is elevated and depressed, the adjustments are perfect; should they deviate, however, from the vertical line, this error may be attributable to two causes: 1st, the line of collimation is not perpendicular to the horizontal axis; or, 2d, the axis is not horizontal, and consequently not parallel to the plane of the rule. In the first case the motion of the cross-hairs will be in a curve, and, upon being made to cover the vertical line when the telescope is horizontal,

will deviate from it to the *same* side both upon elevation and depression. In the second case the movement of the cross-hairs will be in a straight line oblique to the horizontal, and, when made to cover the vertical line when the telescope is horizontal, they will, upon being elevated and depressed, appear upon *different* sides of the vertical line. These two cases will be considered separately.

When the construction of the telescope admits of it, the perpendicularity of the line of collimation to the axis may be examined as follows: Direct the cross-hairs to a well-defined, distant object, as nearly upon a level with the telescope as may be, and draw a line along the fiducial edge; then reverse the rule 180°, again placing the edge along this line, revolve the telescope upon its axis and again observe the object; if the cross-hairs cover it, the adjustment is perfect; if not, one-half the error must be corrected by moving the cross-hairs by means of the adjusting screws of the diaphragm, and the other half with the tangent screw of the table, and the operation should be repeated until the adjustment is complete.

In using the method just given it may be taken for granted that the line of collimation revolves in the vertical plane of the fiducial edge, as any error arising from this not being the case would be inappreciable.

After this adjustment, the horizontality of the axis should be examined. Direct the cross-hairs to a distant, well defined, elevated or depressed object, having the table carefully levelled; draw a line along the fiducial edge, reverse the rule, and again direct towards the object; if the cross-hairs cover it the axis is horizontal; if they do not, one half of the deviation should be corrected by means of the screws attaching the upper plate to the top of the standard, or by means of the screws attaching the standard to the rule. The level attached to the axis should then be made central.

In the alidades, as recently improved, the bearings of the axes being unchangeable, save by such violence as would destroy the instrument for all practical purposes, the foregoing adjustment and the succeeding one are, of course, unnecessary, as the instrument is to be considered as in constant adjustment in these respects.

5. *To make the Line of Collimation Parallel to the Vertical Plane of the Fiducial Edge.*—The exact parallelism of these is not absolutely necessary, but it is essential that the deviation should remain constant. This adjustment may be examined by means of two needles stuck in the table. The table is turned so that the needles sight exactly to some distant object; the fiducial edge is then placed against them and the telescope directed to the object. If the cross-hairs bisect it, the adjustment is correct; but if they do not, it can be corrected by means of the screws attaching the standard to the rule.

6. *Zero of the Vertical Arc.*—When the line of sight is horizontal, the vernier of the vertical arc should read 0°, or the index error should be known. This may be examined by means of the distant sea horizon, or by setting up the alidade so that the centre of the telescope is in the line of sight of an accurately adjusted levelling instrument, and then directing both instruments, while level, to a distant object; if any error be discovered, it may be corrected by setting the vernier at 0°, and adjusting the horizontal wire to the sea horizon or object.

When the above means are not available, the following method may be used: Set up the instrument at a point, measure the angle of elevation or depression of a distant object, remove the instrument to that object, and measure the angle of depression or elevation of the first point. These angles should be equal if the adjustment be correct, and if not equal, the index error will be one-half the difference of the two readings.

The following method of making this adjustment may be employed, where you have neither a separate level, a sea horizon, nor an elevation: Set up the table and level it carefully on any level piece of ground between two equidistant points A and B, say 600 or 800 metres apart. Determine with the table the difference of level of these two points, and remove the table to A. Measure carefully the distance from the ground to the centre of the axis of the telescope, and add or subtract this from the difference of level of the point B, according as it is lower or higher than A. Set up a target or distinct point at this height at B, direct the cross-hairs upon it, and adjust the vernier accordingly.

A longitudinal riding level placed upon the telescope, or a level permanently fastened upon the top of the telescope parallel to the optical axis, and adjusted to the horizontal wire, will give the error at once.

Plane-Table.—With regard to the plane-table proper, a disturbance of its good working condition generally arises from accidents resulting from carelessness or from undue exposure of the board to the inclemency of the weather, and where these injuries are of a serious nature the mechanician only can apply the proper remedies. A coating of shellac has been suggested, whereby the shrinkage and warping of the board is said to be prevented "in a very marked degree;" but well-seasoned wood and fidelity in construction must be the main reliance of the surveyor.

PAPER.—In addition to faulty adjustment of his instrument the topographer has an additional source of error to guard against, arising from the expansion and contraction of the paper, due to its hygrometric nature. From the exposure to which a sheet is subject while in use in the field, and the occurrence of almost unceasing atmospheric changes, it can hardly ever be considered for any great length of time as fixed in its relative proportions; and the difficulty is greatly increased from the want of uniformity in this variation in the different parts of the sheet and in different directions.

In case of trouble with the points arising from this cause, there is but one remedy, and that is by the system of compensation as treated of in the article on field-work.

When points are determined by intersection, the effect of contraction and expansion may be uniform enough to be comparatively unimportant; but in running long traverses without side checks it is always felt.

In plotting long-measured distances the most feasible method of correction is to measure a minute of latitude near the place of plotting; and as the lengths of all these minutes on the sheet is the same, a comparison with the scale can at once be made and the percentage of error determined. When the sheet has no projection, squares of 1,000 metres constructed upon it will answer the same purpose.

Scales.—The very simple and ingenious decimal system of scales for maps adopted by the French is that in use upon the Coast Survey. In this system the scale of any map is represented by a fraction, whose numerator is unity and whose denominator is some multiple of two or five, as $\frac{1}{20000}$, $\frac{1}{10000}$, $\frac{1}{5000}$, $\frac{1}{2000}$, meaning that any distance on the map is one twenty-thousandth, one ten-thousandth, &c., of its actual dimensions on the ground. Thus, on a scale of $\frac{1}{10000}$, one decimetre on the map will represent an actual distance of 1,000 metres.

Any other desirable scale can, of course, be used, as a given number of inches to a mile; and in case of triangulating from a base, as in a reconnoissance, no scale even need be adopted. By assuming two points on the sheet as the extremities of the base, and working from them, a correct delineation of the country can be obtained before the base has been measured. After measurement the scale of the map can be ascertained by dividing the length of the base on the map by its length on the ground, both expressed in the same unit.

In those regions where there is much detail, $\frac{1}{10000}$ is the scale generally used for field-work, while in others, where there is but little minute work, $\frac{1}{20000}$ is employed. Less than the latter is never used for field sheets. In some cases, such as surveys of cities, wharves, &c., $\frac{1}{5000}$ may be used; and in certain rare instances, as in surveys for the location of batteries, the mapping of forts and other works, and sites for light-houses, still larger scales are sometimes found necessary.

The diagonal scales of equal parts used on the Coast Survey with the plane-table, for the purpose of plotting measured distances, correspond with the scales of the maps. They are of metal, and sufficiently hard to stand long wear from the points of the dividers.

PROJECTIONS FOR FIELD-WORK.—The conical projection is that used in the Coast Survey for field-work.

The direction in which the sheet is laid in plotting is determined by various considerations. It should include as many triangulation points as possible; it should duly conform to the position of sheets already surveyed in the same neighborhood; and it should embrace the area of the proposed survey in the manner most convenient for work, and most effective for the artistic appearance of the sheet when finished.

A sketch giving the triangulation points and the approximate shore line (comprised in the area to be surveyed) being before the draughtsman, he proceeds as follows:

The limits of the sheet having been determined, the middle meridian A (see Plate No. 2) is located and drawn, and its intersection with the most central parallel determined, at which point the perpendicular B is erected.

The number of minutes of latitude on the central meridian, above and below the central parallel, being known, take the corresponding distance from Table VI. (" Projection Tables," C. S. Report, 1853, Appendix No. 39), from under the head "Meridional Arcs," and lay it off (C) above and below the central parallel; and, with the same distance as radius, strike arcs (D D D D) above and below from near the extremities of the perpendicular B. With a well-tested straight edge draw lines (E E) through the north and south minutes on the central meridian, and tangent to the two arcs D D, to the right and left. This gives three parallel lines perpendicular to the central meridian.

From the same table (VI.) from under the head "Lengths of Arcs of the Parallels," take out the value corresponding to the number of minutes of longitude, east and west of the central meridian, and lay off the whole distance (F F′ F″) on each perpendicular, taking each distance from its appropriate latitude. Subdivide these into minutes (G G′ G″).

For the areas usually covered by plane-table sheets the corrections (X), for determining the abscissas from the arcs

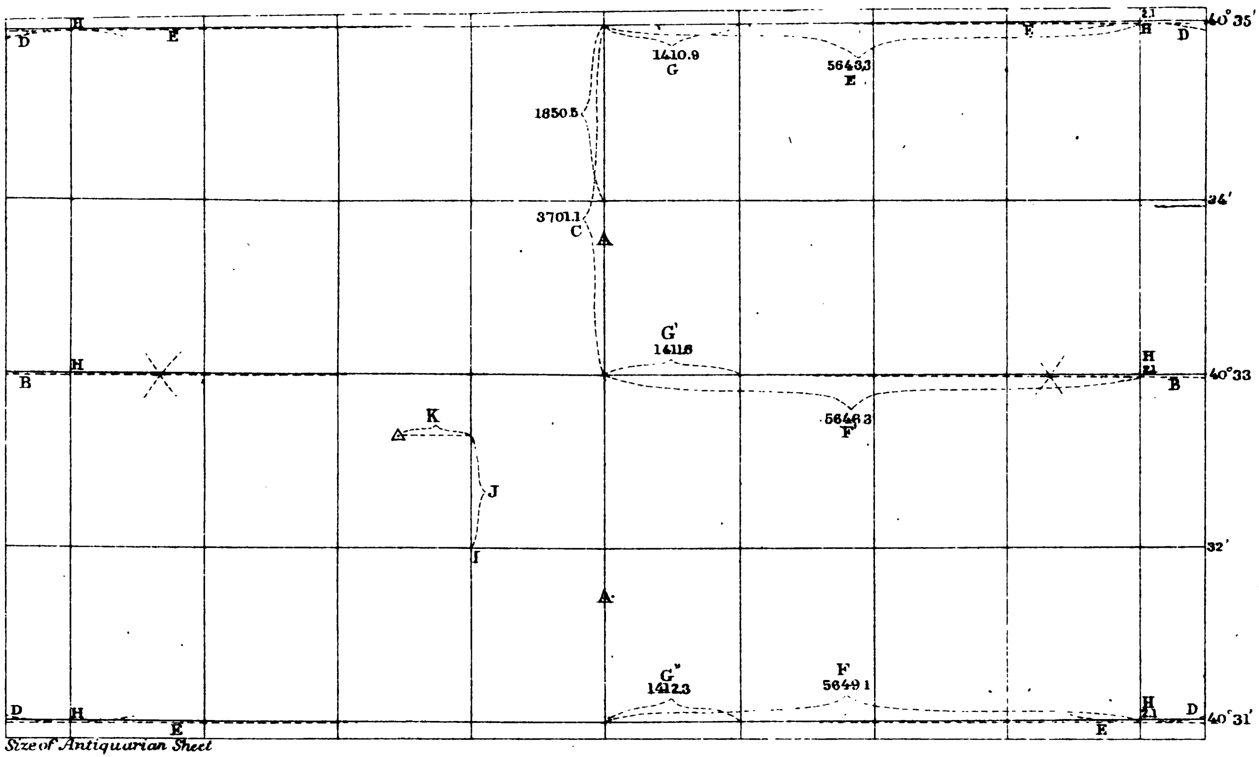


Diagram illustrating the mode of constructing the Conic Projection for Plane Table Work, Scale $\frac{1}{10,000}$

Scale of Diagram, $\frac{1}{80,000}$

of parallels (Table VI., "Co-ordinates of Curvature"), are inappreciable, and may be disregarded; the ordinates (Y) only being used. These give the distances to be set off from the lines B E, perpendicularly towards the pole, for each minute of longitude counting from the central meridian. For ordinary field projections of scale $\frac{1}{10000}$ the ordinate of the extreme minute only need be used, and the parallel drawn a right line from the point so found to the central meridian. This ordinate (H) being set off on each of the parallels, the meridians are all drawn in with a fine ruling pen, then subdivided into minutes, and the parallels carefully ruled in through the points of subdivision.

The projection is verified by applying the measure of a number of minutes of latitude and longitude, and by a comparison of diagonal measurements on different parts of the sheet.

All measurements should be carefully taken from the scale with a keenly pointed beam compass, and the marks pricked in the paper should be as light as possible to be seen, so as to insure the greatest accuracy.

The draughtsman is supplied with a list of triangulation points, which gives their relative distances, their latitudes and longitudes, and also the equivalents in metres of the *seconds* of latitude and longitude, according to which the points are now plotted on the sheet by measuring from the corresponding minutes. Thus in the diagram the distance J represents the seconds of latitude; K, the seconds of longitude of the trigonometrical point.

The accuracy of the plotting is tested by a measurement of the respective distances between the points with the beam-compass, these distances being also given. The degrees and minutes are then plainly marked, usually on the north and east sides of the sheet, at one extremity of each parallel and meridian, the pencil marks erased, and the projection is completed.

It sometimes becomes necessary to base topographical work upon a detached scheme of triangulation before the usual astronomical observations have been made. In this case the only elements given are the distances from the points to two projected arcs of rectangular co-ordinates (which are assumed), and the distances between the points. The projection for plotting these consists simply of axes of X and Y, so laid on the sheet that it will embrace all the points required by the surveyor, and in the manner most convenient for his work; and the points are plotted from these by the intersection of two arcs with the distances of the points from the axes as radii, either north or south, east or west, of the lines of X and Y, as the plus or minus signs given may indicate. The only test is by the distances between the points, and there should be at least two from each. If the work be correctly done, a regular projection can be constructed on the sheet after it is finished, and the required astronomical work is completed.

In case it so happens that for some special purpose it becomes urgent to undertake a piece of topography, when neither the data for projections nor co-ordinates are at hand, plotting by distances is the only resource left, and, of course, great care is absolutely necessary.

It has sometimes been found expedient to carry on a plane-table survey in advance of the triangulation, or where the triangulation has not yet been connected with a base. Under such circumstances it is advisable to draw squares of 1,000 or any specified number of metres on the sheet, by means of which the projection can ultimately be laid down correctly.

FIELD-WORK.—*General Remarks.*—In organizing a party for field-work it is necessary to have one man to carry the table. His duty is to remain constantly with the instrument, to leave it under no circumstances; and while the topographer is at work he holds the shade to protect the chart from the glare of the sun. In some sections the labor of carrying the table is quite fatiguing, in which case another man should be employed with the shade. He should also keep the pencils sharpened, and sometimes, when a careful person, he levels the table, thus giving the operator an opportunity to glance over the surrounding country. He should always have with him a spare piece of rubber, and one or two extra pencils. Two chain-men are needed, and two or three other men with signals, hatchet, telemeter, and other working apparatus, to execute various offices, as they may be required. The maximum necessary for field-work in a plane-table party on land is five hands, and when using a boat, six. Satisfactory work has been done, however, with three, and on very rare occasions with even two men; but, of course, with less facility. More than five and an aid, when but one table is used, is unnecessary, and a less number is a detriment to rapid execution.

The alidade is carried from station to station by the chief of party, resting on the bend of the arm, or hanging easily at the side, and in handling is to be seized by the lower part of the standard, never by the telescope or rule. Some operators prefer to have it transported in the box by one of the men, and handed to them when the table is set up at a station. It usually weighs 8½ pounds; and there is a fear of its being put out of adjustment or injured by falls on rough ground, or in crossing insecure fences, if carried by hand, and a relief is afforded to the arm by being freed for a while from its weight; but one soon becomes so inured to it as to feel but little inconvenience, and carelessness in taking out and replacing it in the box so many times during the day is quite as likely to disturb its adjustments, as is also the fall of the box, or rudely setting it on the ground. The metre scale is best fastened under the clamps which hold the paper to the table, where it is close at hand ready for reference. It has been suggested that it would be an advantage to have it engraved upon the rule of the alidade, and it has also been proposed to have the scale drawn upon the sheet, and thus afford a correction of error of shrinkage, but its constant use would soon seriously deface the paper. The pencils, dividers, and India-rubber can be carried in an outside breast-pocket, the points of the dividers, when not in use, being thrust into the edge of the rubber. The little metallic patent pencil-holder, pinned upon the left breast of the coat, is used satisfactorily by some surveyors for this purpose. A handy and compact arrangement + for carrying the scale, pencils, etc., is a russet leather case 10½ by 2¾ inches. It is made large enough to accommodate, on the opposite sides of the scale, when it is in, three or four pencils, and the dividers protecting the points of both; the whole carried in a leather pouch 11 by 4½ inches, slung over the shoulder, the pouch accommodating also note-books for sketching, table of heights, extra pencils, and rubber; everything being at hand and well protected. When the table is set up the dividers and pencils are taken from the case and laid upon the table, and the scale drawn out as needed. Some topographers object to carrying the scale upon the table under the clamps, because it is liable to soil the paper, to drop out in passing from station to station, is not always in the

The linen is placed on the table before the paper is put. The edges of the linen are folded over the edges of the ber, and then roll part. The rule is placed on the linen under the clamps. +

LIBRA OF THE UNIVE CALIFO

most convenient place for use, and sometimes interferes with the play of the alidade.

It is well to have ready a light India-rubber cloth cover to slip over the board in case of a sudden shower, as well as to protect the paper from the dust on the roads, mud in swampy ground, or water where a boat is used in going from one station to another. The sides of the sheet where they are turned under the table, and come more or less in contact with the coat of the observer, should be protected by strips of paper about four inches wide, and six inches longer than the side of the table, so as to fold under it and clamp on with the sheet itself. Tracing vellum is good for this purpose, as the points on the edge of the sheet can be seen through it. A plan followed by some topographers, is to cover the whole sheet, as exposed on the table, with thin paper, tearing it away at those points only where they are at work, and covering again by pasting on patches as soon as finished, thus protecting as much of the sheet as possible; but in determining points this is impracticable.

The plane-table must never be rudely handled, never roughly set on the ground, nor carried heedlessly through woods or swamps, and the weight of the body or arms should never rest upon it. Instructions should be given the men that, under no circumstances, except in cases of threatened danger, should the table or instruments connected with it be touched during the temporary absence of the topographer.

#8.

To prevent oil from getting on the paper the topographer wears cotton gloves

Preliminary Work.—As an indispensable preliminary to the operations of field-work, the topographer must assure himself of the correctness of the plotted points on the sheet, by an examination of them in the field, either by actual occupation of each one, or of a sufficient number to embrace them all in two or more lines of observation. When this has been done, and the points found correct, or properly adjusted (as shown further on), the regular survey is commenced.

It is very rare that a sufficient number of triangulation points furnished, or their positions, are such as to suffice for carrying on an extended survey without the aid of intermediate points. These are to be determined by the plane-table, and this can be done over a whole or a portion of the sheet, either before any filling in of the topography is done, or during the progress of the work, depending much upon the character of the country and the skill and judgment of the topographer.

Sometimes, from lack of natural objects, it is found advisable to go beforehand over the country and locate signals in suitable points for subsequent determination and use. In the location of signals, either as permanent points or simply for temporary forward lines, a great deal depends upon the good judgment of the person placing them. Two purposes are to be subserved; first, the seeing a sufficient number of known points to give a good determination; and, second, to command a view of as great an area of country, and of as many natural and artificial features for filling in the topography, as possible. It should be remarked, also, that in the course of the prosecution of the regular work, no favorable opportunity must be allowed to escape for locating a signal or determining a point which may at some future time be of service. Advantage should be taken of open places in the woods commanding roads or ravines. Piers or draws of bridges, or piles, giving lines up and down streams, with precipitous or bluffy and wooded banks; trees of unusual appearance in prominent positions, or bearing flags placed upon them for the purpose ; points of rock, off-shore or otherwise ; lightning-rods, cupolas, weather-cocks, chimneys of factories, and other peculiar and marked objects come within this category. In fact, it may be set down as a rule, that well-determined signals located at convenient distances over the sheet are more likely to be too few than too frequent.

Signal poles should be straight and perpendicular, the flags upon them adapted in color to the back-ground against which they will be seen when observed upon, protected from cattle in settled districts by earth thrown up or by stones piled about their bases. They should also be well marked with pegs, or by measurements to neighboring permanent objects, so that in case they are disturbed their positions may be found.

It is taken for granted that some facility in the manipulation of the table is already arrived at, as well as a knowledge of conventional topographical signs, and the application of them ; it being merely necessary to remark that on maps of a large scale it is required to plumb the plotted point exactly over the station, although on the usual field scale an approximation with the eye is all that is requisite, and that all lines should be drawn lightly and carefully close to the edge of the rule with a finely sharpened hard pencil, and that in sketching one somewhat softer is used. If the table and alidade be in proper condition, the contact of the fiducial edge with the paper will be perfect throughout its whole length, and in drawing a line along the edge care must be taken to preserve the same inclination of the pencil, and to avoid a "shoulder" in the pencil itself. If the rule be at all raised from the paper at any part, still greater care is to be observed, lest the point of the pencil should run under the edge and thus deviate from a straight line.

It is well for the beginner to learn to observe with his left eye as well as the right, for obvious reasons.

The instruments should be kept scrupulously clean and free from sand or grit, and work with the table should cease the moment the presence of any foreign substance between the surfaces which play upon each other is suspected. An occasional taking apart of the table and cleaning with soap and water, using soft linen rags for the purpose, will be found necessary; and, after being oiled and put together, it should be wiped thoroughly dry. The cleaning should not be intrusted to any person unaccustomed to the handling of instruments.

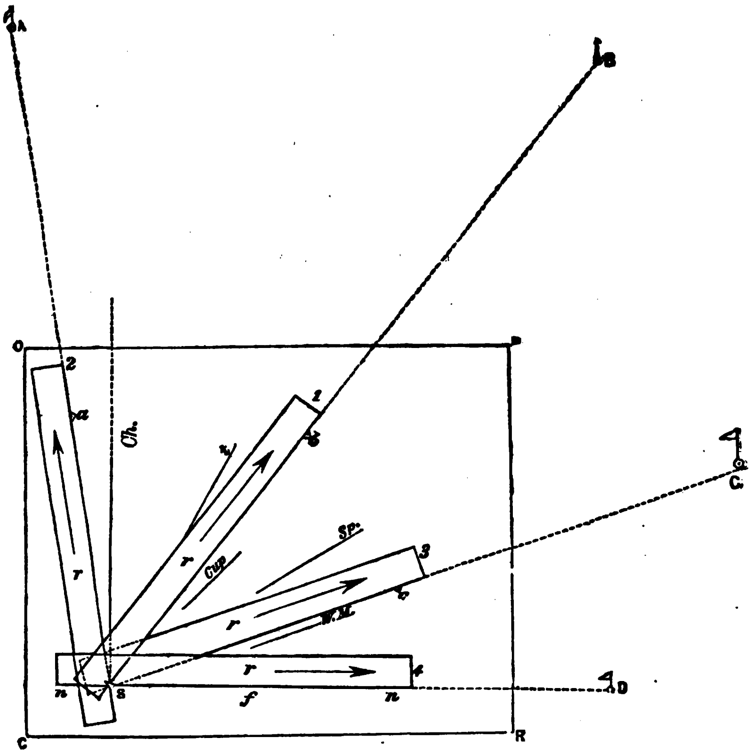
In observing upon signals which are not perpendicular, the sighting should be as nearly as possible upon the base of the pole.

FIELD PRACTICE.—Topographical points can be determined by three methods, viz.: intersection,* "resection," and measured distances. In the first of these the point must be seen from two or more occupied points in suitable positions, with regard to the point to be determined; in the second, it must be occupied; and in the third, there must be a direct measured line, with an established direction from the occupied point. These methods of determination, and the incidental operations which accompany them, will now be considered.

---

* Custom has given this general term a specific signification in Coast Survey topographical work.

Fig. 1.



Let O, P, Q, R., Fig. 1, represent the board of the plane-table, upon which is spread the topographical sheet; the plotted triangulation point *a* upon the sheet representing the signal A upon the ground; *b*, the spire B; *c*, the signal C; and *s*, the station S; the small letters on the sheet representing the centres of the signals on the ground, which are referred to by corresponding large letters.

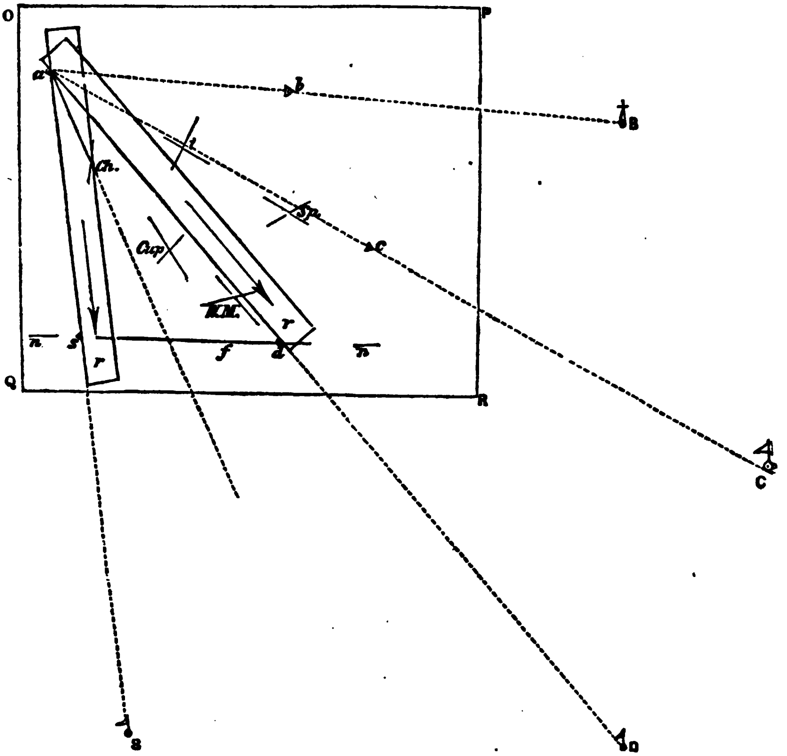
The table is first placed approximately level over the occupied station S, and put in position, also approximately, by the eye, so that the plotted points on the sheet are in range with the station S and the signals or objects they represent in the field. Then plumb the point *s* over the station S, fixing the legs of the table firmly in the ground; place the alidade upon the table so that the rule shall extend across its centre; loosen the large milled head screw projecting below the top of the stand, and by means of the levelling screws bring the bubble of the circular level on the rule to the centre. Place the alidade at right angles to its first position upon the board, repeat the operation, clamp the large screw again, and the table is level. Now free the tangent screw by loosening its clamp, place the edge of the rule *r* upon the occupied point *s* and the point *b*, the telescope being directed towards the spire B, as shown by the arrowhead in the figure, and revolve the table horizontally about its centre with the hands until B is seen in the field of the telescope; clamp the tangent screw and turn it till the intersection of the cross-hairs bisect the top or centre of the spire B. The table is now "in position," if the plotted points be correct and the proper objects sighted. In other words, the table is "oriented" when the point observed upon and the point occupied are in the line of sight, the edge of the rule being upon the two plotted points; the one, *s*, perpendicularly over the occupied station, and the other, *b*, the station observed upon. As a test of the correctness of this, place the rule upon the point *s* again, and upon the points *a* and *c* consecutively, and if the two signals A and C are covered by the vertical cross-hair of the telescope, the orientation is assured, and the meridian of the sheet is parallel to that of the earth, all the lines joining the signals and their respective projections being also parallel.

It will sometimes happen that the upper metal disk attached to the table, after it has been clamped and the tangent screw used to put the table in position, has a tendency to spring still further with a sudden movement or slight jerk, and this movement may not occur until impelled by the ordinary working about the table, and pass unobserved by the operator. This may arise from the two disks being screwed too closely together, and the faces in contact not being sufficiently oiled. It is often the source of much trouble to the beginner, and he is unable to discover the cause. It is well, therefore, in orienting the table, when this is suspected, to take hold of the edge of the board with the thumb and finger and spring it very slightly from side to side, in order that the table may settle itself in a fixed position. The cause of the trouble must, of course, be removed on the first opportunity.

The next operation is to " take the forward line " to the next point which it is desirable to occupy or determine, either some natural object which can be occupied, or a forward signal placed for that purpose, say the signal D.

The edge of the rule is placed upon the point *s* and moved about that point as a centre until the forward signal D is covered by the vertical hair, and then a line, *f*, is drawn along the edge of the rule from *s* sufficiently far to reach the estimated distance on the sheet of the point *d*, and at each end of the rule the short check lines *n n* are drawn. In the same manner lines to be afterwards intersected should be drawn to such objects as it may be well to determine. To prevent confusion the ends of such lines are marked as in the diagram: *ch.*, chimney; *t.*, tree; *cup.*, cupola; *sp.*, spire; *w-m.*, wind-mill, etc. Tangent lines and lines radiating to objects comparatively near at hand, to be chained or obtained by the telemeter, as fence, corners, etc., should be likewise taken. If the station occupied be in an elevated and prominent position, its height should be observed, both as a guide for putting in the contours at the point, and to serve as a point of reference in taking heights at other places, the method of doing which will be given hereafter. The necessary sketching is now done, omitting nothing that can be completed from this point; the alidade removed, the table raised, the signal put up, and the party leaves for the next station. Sometimes it is necessary to start the chain from the station to the forward signal.

Fig. 2.



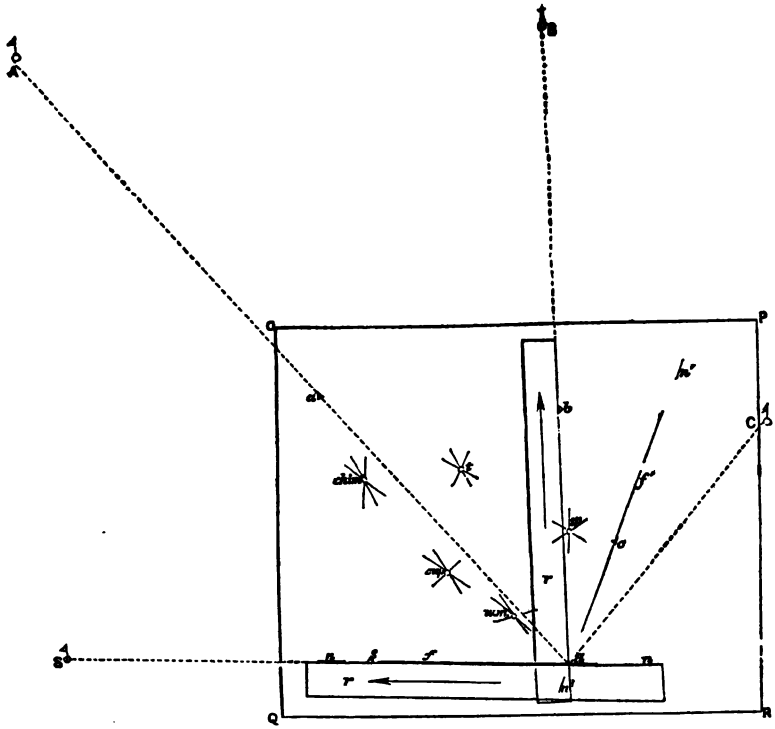
When moving from one station to another it is the custom with some topographers to loosen the tangent clamp, with the idea that if the table come in contact with any object while being transported, it will revolve and be less liable to injury. This perhaps is true, if the blow comes on the side of the table only, and in the direction of its plane.

Now, let the letters in Fig. 2 be the same as in Fig. 1. The table is removed to the station A and placed over the point on the ground, put in approximate position, levelled, clamped, and loosened at the tangent screw, as at station S. The rule is then placed upon the line *a s*, the cross-hairs of the telescope directed towards the signal S, and the table brought into position, as before described. Then keeping the edge of the rule upon *a*, direct the telescope upon the signal D, and draw the line *a d*, intersecting *f*, and determining the position of the point *d* upon the sheet, corresponding to D, and bearing the same relation in position and distance to the points *s*, *a*, *b*, and *c*, as the signal D does to S, A, B, and C. All the other objects to which lines were drawn from *s*, and which can be seen from A, are intersected and determined in the same manner. This is an example of the method of "intersection."

The necessary sketching, determination of height, etc., are executed here as at S, and, indeed, at every point occupied,—it being desirable, if possible, never to occupy a a station more than once.

The intersection of two lines is not, however, positive evidence of the correct determination of a point. Let us, therefore, proceed to D and again determine it by "resection" from the point B. (See Fig. 3.)

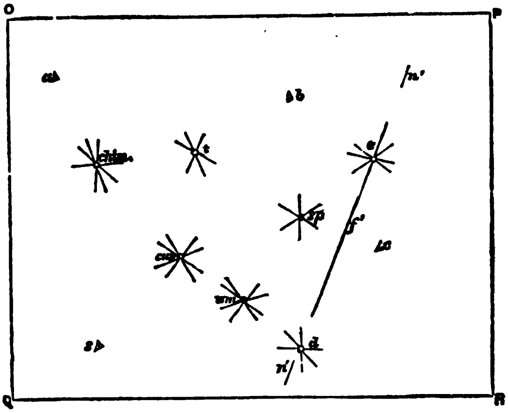
Fig. 3.



The table is placed over the point D, put in approximate position, levelled, etc., as at the other stations. The rule is then placed upon the forward line, *f*, (now called the "back line," as seen from D,) passing through the point *s*, so that the checks *n n* are just visible along the edge, and the telescope directed towards the signal S, as shown by the arrow, and the table oriented. The rule is then placed with its edge bisecting one of the plotted points, such as *b*, which will give a cleanly cut angle (the nearer 90° the better) with the line *f*, and is moved about that point as a centre until the spire B is covered with the vertical hair. A line is now drawn along the edge of the rule, crossing the line *f*. If this line intersects *f* at precisely the same point as the lines *f*, *a*, and *d*, the position of *d* upon the map is assured, and a delicate hole with the point of the dividers should be pricked upon the sheet to fix the point, surrounded by a small circle in pencil. The point may be still further tested by resection from C. If the forward line from *s* has also been chained, the distance taken from the scale and laid off from *s* on the line *f* will afford still another test, and it is quite sufficient if it agree with an intersection where only one can be obtained.

Another forward line, *f′*, is now taken, with the usual checks, *n′ n′*, to the next desirable station, and lines of intersection are also drawn from *d* upon the chimney, windmill, cupola, tree, and spire previously observed, as they appear in the telescope, in succession from left to right, and their positions definitely fixed upon the map, pricked through and marked; and these being well determined, can now be used for the determination of other stations. New lines to such other objects as may be thought necessary should be taken, as well as tangent lines, and then follows the sketching to fill in the details about the station.

Fig. 4.



The table is now removed to E, Fig. 4 (which it was thought unnecessary to mark on Fig. 3), through which the forward line from *d* is supposed to pass, and is placed over the station; and the point *e*, representing the projection of the signal E upon the map, is determined by resections by the use of the line *f'* and the points *s*, *a*, *b*, and *c*, although the latter two are not absolutely necessary. The spire and tree may also be used for this purpose. Those points which, owing to acute intersections, have been insufficiently determined, as the chimney, cupola, and wind-mill, are again intersected. Other intersecting lines are taken from *e* upon other points which present themselves, the necessary sketching made, and a new forward line taken to the next station.

During all these operations occasional recurrence should be had with the alidade to some established point to assure the immobility of the table, or to correct any deflection from the true position which may have taken place.

If upon going to a forward signal or object to which a line has been taken it is found that it cannot be occupied, or that it is in such a position that a sufficient number of points cannot be seen from it, or, for any reason, it does not answer the desired purpose, a point in range between the two stations, or upon the prolongation of the line connecting them, can be occupied. Getting into line between two stations is performed by two persons standing facing each other, about thirty metres apart, and as nearly on the line as possible, one of whom sees the back and the other the forward signal. Each then moves alternately to the right or left, as directed by the other, until each signal is in line with the person whose back is towards it, as seen by the person facing it. The table can then be readily placed anywhere on the line. A position for a point beyond the forward signal may also be found by simple alignment with the two signals.

When by accident in drawing a forward line from an occupied point, near which upon the sheet is plotted another or several other points, the rule is not set upon the point occupied, and the error is not manifest until the forward signal is reached; instead of going back to take the line over and draw it from the last station, it can be constructed by drawing from the correct station a parallel to the false line.

Points and lines.—The accuracy of the work on the topographical sheet is primarily and mainly dependent upon the correct determination of points, and a want of an exact knowledge of the capabilities of certain points already determined to ascertain the observer's position upon the sheet, as well as the positions of other points, is one of the greatest sources of trouble and error to a beginner. When a survey is commenced with slightly faulty points, and uncompensated as the work proceeds, the scale upon which it is executed becomes variable, and consequently erroneous.

When, as we have seen, a triangulation point is occupied, and lines drawn from a number of other plotted points, with the table in position, intersect perfectly at that point, the position is assured; but when they do not thus intersect, the cause of the difficulty may be found either, 1st, in errors of triangulation or computation; 2d, in a faulty projection, or plotting of the points; or, 3d, in the unequal expansion or contraction of the paper. The first two, when at all great, can only be corrected by a revision of the work of triangulation and projection; and the latter, if not sufficiently large to warrant an entire rejection of the sheet, can be remedied only by the judicious action of the topographer, with the plane-table, in the field.

When the points disagree within quite moderate limits, the practised hand can, by distributing the error among the points in the proportion of their distances from the occupied point, so reduce the effect of the sum of these distributed errors on the position of the occupied point that he may be safe in considering positions determined from his point, so corrected, as more accurate and trustworthy than the plotted points themselves, and use them as such. A maximum error of twenty metres on a scale of $\frac{1}{10000}$ can generally be reduced at the point of intersection to an almost, if not quite, imperceptible quantity.

The topographer should be very chary in rejecting points as unfit for use. No matter what the apparent disagreement may be, one should not hastily throw aside one set of points and accept another because one set *appears* to agree and the other to disagree. But the positive occupation of a series of points of whose accuracy you thus become sure, and another series of whose inaccuracy you are equally satisfied, renders the preference of one set over the other at times not only permissible but obligatory. It should always be remembered that absolute and careful investigation in the field, and close examination of the projection, plotting, and data of triangulation, ought to be made before any point or set of points is condemned.

THREE-POINT PROBLEM.—It is often expedient to place the table in position at an undetermined point without any "back line." With three signals in view whose positions are projected on the map, the table can be oriented, and the point determined by means of the "three-point problem."

The table is brought into approximate position by the eye or declinatoire, and, not being properly oriented, the lines drawn from the three projected points will not inter-

Class 3.—When the point sought falls without the great circle and within the sector of either angle of the great triangle, the true point is on the same side of the line from the middle point as the intersection of the lines from the other two points. (Case 4.)

In case the point sought falls on the range of any two of the points, and the table is deflected from true position, the lines from the two points will be parallel, intersected by the line from the third point. But this range can always be determined by alignment, the table set in position on the range, and the point occupied determined by resection on the third point. (Case 6.)

In case the point sought falls *near* the range of any two of the three points, the lines from the two points are so nearly parallel that their intersection falls off the table, but the relation of the true point to the triangle of error is in no way changed.

The accompanying diagram shows the fields embraced by the classes given above, also the location of each of the cases included in those classes.

A point on the circumference of the great circle being indeterminate, it is apparent that a determination should never be attempted in close proximity thereto.

The following cases are believed to include all possible conditions of the relation of the position of an undetermined point to three fixed points. The surveyor is supposed to face his signals and the directions right and left given accordingly.

Case 1. (Figure 1, Plate No. 4.)—When the point sought is within the great triangle the true point is within the triangle of error.

a b c are the projected points, and *ab ac bc*, the false intersections from them forming the triangle of error.

Rule.—If the line from any one of the points falls to the right of the intersection of the other two, turn the table to the left, and if to the left, turn it to the right.

When the point sought is without the great triangle the true point is also without the triangle of error, and is situated to the *right* or *left* of it, according as the table is out of position to the *left* or *right*.

Case 2. (Figure 2, Plate No. 4.)—When the point sought is without the great triangle and within the great circle, the true point is without the triangle of error, and the line drawn from the middle point lies between the true point and the intersection of the other two lines. This also includes Case 3 (Figure 3, Plate No. 4), which rarely occurs in practice where the three points are in a straight line.

Rule.—If the line from the middle point is to the right of the intersection of the other two, turn the table to the right, and if to the left, turn it to the left.

Case 4. (Figure 4, Plate No. 4.)—When the point sought is without the great circle, and the middle point is on the far side of the line joining the other two points, the true point is without the triangle of error, and upon the same side of the line from the middle point at the intersection of the other two lines.

Rule.—If the line from the middle point is to the right of the intersection of the other two, turn the table to the left; and if to the left, turn it to the right.

Case 5. (Figure 5, Plate No. 4.)—When the point sought is without the great circle, and the middle point is on the near side of the line joining the other two points, the true point is without the triangle of error, and the line drawn from the middle point lies between the true point and the intersection of the other two lines.

$\angle dse = \angle dce$ and $\angle dsg = \angle dag$
$\angle dce = \angle dbe'$ and $\angle dag = \angle dbg''$
Therefore $\angle dse = \angle dbe'$ and $\angle dsg = \angle dbg''$
also se parallel to be' and sg parallel bg''
and the triangles sle and blf are similar,
and the triangles slg and blh are similar;
from which we get $le : lf :: ls : lb$
and $lg : lh :: ls : lb$,
also $le : lf :: lg : lh$ and $le : le - lf :: lg : lg - lh$
that is $el : ef :: gl : gh$ or $el : gl :: ef : gh$.

[illegible]

The amount of the angle at l is always an indication of the value of the determination of the point sought. The more obtuse the angle the better the determination.

BESSEL'S METHODS.

Bessel gives two methods, both based on the same principle.

First method. (Figs. 11, 12, and 13, Plate No. 4.)—

Let a b and c be the projections of the three points observed upon, and ab bc ac, the triangle of error formed by resection upon them when the table is not in position. Lay off bc' on $ba = bc$, extend bc and lay off $ba' = ba$. Call the angle at the intersection $ab = x$, and that at the intersection $bc = y$. At a' lay off toward you $\angle ba'e = \angle y$, and at c' in the same direction $\angle bc'e = \angle x$. The lines so laid off will intersect in e, which lies in the line of sight through the middle point b and the point sought, (d). By resection upon a and c, the position of the point on this line is fixed.

The solution of this is as follows (Figure 14, Plate 31):

Lay off at a the angle $bae = \angle bdc$, and at c $\angle bce = \angle bda$, drawing the line bc, $\angle ebc = \angle abd$ and $\angle eba = \angle cbd$. Produce bc to f, so that $bf=ba$, and draw fg parallel to ce. Lay bfg on ba, so that f falls on a and g on h.

Then we have in the quadrilateral $ahbe$ and $abcd$

$$\angle bae=\angle bdc,\quad \angle hbe=\angle abc$$
$$hb : be :: bg : be :: bf : bc :: ba : be.$$

The two quadrilaterals are therefore similar, and hence

$$\angle ebc=\angle hba=\angle abd$$
$$\text{and } \angle eba=\angle cbd.$$

Second method.—The plane-table may also be put in position without the use of the points a' and c'. (Figures 15, 16, and 17, Plate 31.)

On ac at c lay off $\angle ace=\angle x$, and at a lay off $\angle cae=\angle y$. The lines so laid off will intersect in e, which lies in the true line of sight through the middle point b and the point sought, (d). Resection upon a and c then fixes the position of d.

The angles e and d of the quadrilateral $aecd$ make up from the construction two right angles*; hence a circle may be described about the quadrilateral, and we have the periphery angles

$$ace=adb$$
$$\text{and } cae=cdb.$$

This latter method, being simpler, is better than the first, but, under certain circumstances, one may be used when the other cannot. If, for instance, by the last-mentioned manner of construction the point of intersection (e), should fall outside the plane-table, it may possibly be made to fall inside by the first method. Again, if, by the latter method, the angles of intersections happen to be right angles, or nearly so, then the two plotted lines to e be-

* because adb + bdc = x + y [illegible] x + y
180 − ½ a, on ade Δ and ∴ ∠e = 180 − (x + y)
∴ ∠e must be measured ½ arc
in circumference through A E & D, one

[illegible] of [illegible] measures
is equal a circum. divided by

come parallel to each other, or nearly so, in which case the first method may be used with advantage.

The best mode of constructing the angles *x* and *y* upon *ac* is with the alidade; directing the line to one of the objects and observing the other object with the alidade set upon the point at which the angle is to be set off. It can also be readily done with the dividers by laying off the chord of the angle.

Should either or both of the angles set off at *a* and *C* be so obtuse that the point *e* falls off the table, a shorter base can be used, drawn parallel to *ac*, as near to *b* as may be necessary.

TWO-POINT PROBLEM.—The occasion may arise where it is desirable to place the table in position at a given point, from which point only two determined points are visible. This may be done by the following methods. The first mode possesses the virtue of making no linear measurement, and demonstrates in a very satisfactory manner the power of the table in determining position by resection. (Figures 18, 19, 20, and 21, Plate No. 4.)

Two points, A B, not conveniently accessible, being given by their projections *a b*, to put the plane-table in position at a third point C: (The capital letters refer to points on the ground and the small ones to their corresponding projections).

Select a fourth point D, such that the intersections from C and D upon A and B make sufficiently large angles for good determinations. Put the table approximately in position at D, by estimation or by compass, and draw the lines A*a* B*b*, intersecting in *d;* through *d* draw a line directed to C. Then set up at C, and assuming the point *c* on the line *d* C, at an estimated distance from *d*, and putting the table in a position parallel to that which is occupied at D, by means of the line *c d*, draw the lines from *c* to A and from *c* to B. These will intersect the lines *d* A *d* B at points *a'* and *b'*, which form with *c* and *d* a quadrilateral *similar* to the true one, but erroneous in size and position.

The angle which the lines *a b* and *a' b'* make with each other is the error in position. By constructing now through *c* a line *c d'* making the same angle with *c d* as that which *a b* makes with *a' b'*, and directing this line *c d'* to D, the table will be brought into position, and the true point *c* can be found by the intersections of *a* A and *b* B.

Instead of transferring the angle of error by construction, we may conveniently proceed as follows, observing that the angle which the line *a' b'* makes with *a b* is the error in the position of the table. As the table now stands *a' b'* is parallel with A B, but we want to turn it so that *a b* shall be parallel to the same. If we therefore place the alidade on *a' b'* and set up a mark in that direction, then place the alidade on *a b*, and turn the table until it again points to the mark, then *a b* will be parallel to A B, and the table is in position.*

We can now find *c* and *d* by intersections in the usual way.

Another method is as follows: (Figure 22, Plate No. 4).

Two points, A and B, not conveniently accessible, being given, to put the plane-table in position at a third (undetermined) point, C.

Set up the table at the point sought as nearly in position as can be done by the eye, and resect upon A and B, intersecting the line *bc* at *c'*. The angle *ac'b* is the true angle at the point occupied, subtended by A B, being the

*the mark then set. a b. must be dist[illegible] or error will arise [illegible]
to [illegible] [illegible] a'b' & [illegible], slight [illegible]
a'b' [illegible] [illegible] a b

* [illegible] ∠ a ration = required ∠. The vertex of latter must be on circumference of circle through a b + c' least at in order to be measured by arc at opposite

the angle of nature actually drawn; therefore, the true point must be on the circumference of a circle passing through *abc*.* Construct this circle. Measure off a reasonable base, C D, at right angles, or nearly so, to BC in either direction most convenient. Set up a signal at D, and with the alidade draw the line *c′ d*. Remove the table to D, and, by means of a signal at C, (the point sought,) and the line *dc′*, bring the table into a position parallel to that which is occupied at C. With the alidade centring on *d*, observe the signal B, and draw the line *db′* intersecting *cb* at *b′*. *c′ b′* is the distance of the point C from B, and this distance laid off on the circle *acb′* as a chord from *b* will give *c″*, the true position of the point C. A fourth point may then be occupied, and by resection of A B and C the accuracy of the determination of C verified.

Where it is possible to get the two signals A and B in range, it is easy to determine the position of a third point by a mode long practised by topographers.

Set up the table anywhere on the range line, and, having set up a signal at the point sought, resect upon it, intersecting the range line anywhere, and, by means of the range signal and the line to it, the table may be set in parallel position to that occupied in the range, which is the true position, and the point sought may be determined by resection upon the two fixed points and their projections.

Fɪᴇʟᴅ-Wᴏʀᴋ.—In taking lines of intersection upon a point or object from a series of stations, when these lines do not coincide in one point, as they are usually derived from signals at unequal distances, the error should not be divided equally among them, but in proportion to their lengths.

It should be borne in mind that very short lines from

The Range were placed where [illegible] [illegible] were first set up

* Because when the table oriented
at D, c'b parallel to CA on grou
∴ similar Δs

a determined point,—as, for instance, to the corners of a fenced road, where the table occupies the centre of the intersection of two roads—may be taken with no apparent error when the table is deflected to some extent from its true azimuth, but that in this case a prolonged line will be considerably out at its further extremity.

A long line should never be obtained by the prolongation of a short one from a back station where there is no small check line, or some other point in that prolongation already fixed.

It will be apparent that the more nearly at right angles intersecting lines cross each other, the more clearly the point will be defined; acute intersections, as far as possible, should be avoided, and, even when they are crossed by a third line at a satisfactory angle, a fourth line, or an accurately chained distance from a well determined point, is advisable. angles should be between 30° + 150°

The necessity for dependence upon a measured line, with an established direction alone, for position, is sometimes unavoidable; but, except for minor details, it should never be resorted to when other means are available. Occasional checks are very important, and, in a finished piece of work, no lengthened consecutive series of chained lines for positions should be trusted without resections, for tests of accuracy. It is safer to combine both, unless the supply of signals is ample and they are favorably located.

A judicious use of range lines from established points, or signals, will much economize time and facilitate work.

Two range lines from well-determined points are equivalent in value to four intersecting lines.

Tangent lines can only be used for determining the edges of woods, bends of streams, sweeps of shore-line, outlines of shoals, small ponds, and the outlines of other objects when in unimportant localities, and are inadmissible for any purpose in which accuracy of delineation is expected, save when they form a polygon, by which absolute convexity at all points is to be represented, and even then the points or objects should be visited and sketched if possible.

Where the topography surveyed includes the shore line of a body of water, the hydrographic survey of which is intended to follow the topographical work, as in the Coast Survey, it is the duty of the topographer to locate and determine the shore signals, and it is only necessary to state that they should be so placed as to furnish the hydrographic party with as many points as is desirable for the determination of positions on the water.

It is well to mark all stations occupied along or near the shore by pegs driven into the ground, with stones about them, and give their positions upon the tracing furnished the chief of the hydrographic party, and he can then select such as are best adapted to his use.

Natural or artificial objects along the shore, or in plain sight from the water, such as fence ends, rocks, prominent houses, and posts on wharves, etc., should be determined and marked upon the sheet. As some time may elapse between the labors of the two parties, the stations should be well secured above the wash of the tides.

Lines to buoys and other permanent floating objects should be, as far as practicable, taken at the same stage of the tide, or direction of current, or the status of the tide noted at the time of observation.

In the determination and tracing upon the chart of the low water line, so much in its outline is generally dependent upon the direction and force of the wind that no fixed rules for guidance can be given.

The delineation of the ordinary mean low water mark should be aimed at, and when it is beyond the reach of the plane table, and presents no marked points for determination, or is of a character that will not admit of putting up and working the instrument—as along the swampy shores of the South, where the muddy shoals extend far seaward, and among the shifting quicksands of our great estuaries and bays—it must be left to be traced by the soundings and tidal reductions of the hydrographic parties.

It is always best to determine the high and low water lines, both at spring and neap tides. Having learned the range of tide, the topographer will know how long he can work without error.

Where, on the occurrence of any great or unusual storm or freshet during the working season, the low water line, which has already been surveyed, is found to have changed in form or locality, it should be resurveyed, and both the old and new outlines retained on the sheet, with the appropriate notes.

As a feature which is quite interesting and important under certain circumstances to the hydographer, low water springs, having their origin and outlet below the high water line, should be shown on the chart, where it can be done, in the regular routine of work. All grassy shoals should be delineated. They are always found in water scarcely agitated by waves or currents, and their shape and outline on the channel side is a very marked feature, and a good measure of the power of the current. Eel grasses should also be put upon the map, as indicating an antecedent accumulation of fine sand or soil.

Orientation by the declinatoire or compass-needle, alone, is not reliable, unless for obtaining positions for rough sketching in plane-table reconnoissance, but it may be useful as an adjunct when an operator, in default of sufficient points, desires to obtain an approximate position. It is used by placing the straight edge of the box containing the needle upon a magnetic meridian, previously traced upon the chart, and revolving the table until the needle points to 0°, or north, on the graduated arc in the end of the box. When the declinatoire is fastened to the rule, the edge of the rule is used. The magnetic meridian is roughly obtained at any well-determined station, when the table is properly oriented by the use of the declinatoire itself, the meridian line being drawn upon the sheet along the straight edge of the box when the needle points to 0°.

In sketching or drawing, care should be taken not to lessen the size of natural objects, the scale being followed as far as practicable ; but in some cases, which will be apparent, it may be desirable to enlarge somewhat, but very cautiously. The topographer should learn to draw from nature readily, and at once, without being obliged to erase or interlineate. By working carefully at first this will be obtained in due time.

Too frequent use of the India-rubber disturbs the fibres of the paper and renders the subsequent inking less neat and clear. The drawing should be plain and distinct, so as not to be obliterated easily by the movement of the alidade over the paper, but not so dark or heavy as to blur. The object should be solely to represent accurately the surface and elevation of the country surveyed, and it should be easy and natural, and not a stiff copy of conventional signs.

Nothing should be left uncertain or indefinite, to be afterwards puzzled out or guessed at. As far as practicable, all work should be drawn in the field under the eye.

Sketching and plotting in the office from notes is objectionable, unless the country be near at hand for examination in case of doubt or a defective sketch, or of error of chaining.

Too great care cannot be taken in the manipulation of the plane-table. There should be no pressure, and in moving the alidade, both it and the arm should always be raised clear of the board, so as not to rub over the surface of the sheet.

The topographer should learn to distinguish, as a matter of economy in point of time, between the relative importance of different topographical features. While it should be the object to do all the work correctly, yet a line should be drawn between the expenditure of time necessary to a correct representation of the thickly-settled streets of a town and the bend of an unimportant creek in an obscure and out-of-the-way swamp. Experience alone can teach a proper discrimination in this respect.

CONTOURS.—If there be any feature which more peculiarly distinguishes one section of a country from another, imparting to it its most striking characteristic, and to which all other accidents of ground are subordinate, it is to be found in the inequalities or changes of the level of the surface, and it is the correct representation of this feature that calls forth the best skill and judgment of the topographer, and upon which the value of a map most materially depends.

Previous to the commencement of work, it is well to become possessed of some knowledge of the country which is to be surveyed. A rapid examination of the ground, by showing whether it lies in regular parallel ridges and intervening valleys, isolated hills, gradually sloping plains, or broken, abrupt, and rocky declivities, and whether partially or entirely open, or wooded, will suggest to the topographer the best method of operation, and enable him to form a general plan of work which will result in economy in point of time, and, as a consequence, will preserve the continuity of contour from day to day as the work progresses.

By keeping in view the characteristic features of the hills in the section of country under survey, the topographer will be able to give a naturalness to a sheet, which, by a mere formal, though correct, delineation by prescribed rules, he could not effect. It is to be observed that the elevations and depressions, in their form and course, follow, or rather are a part of a general system of nature, however capriciously detached localities or even extended areas may appear to be excepted from the general law. Where these exceptions are found they can usually be traced to some breach of or interference with this law, and will be found to be confined solely to the locality where the disturbing causes have operated.

Thus the principal ridges will be found to tend in one general direction, either running parallel with the main range which lies farther off, or forming spurs at right angles to it. Along the coast the latter is generally the case, as we there usually find the spurs, or the extremity of some main prominent inland range. When a single detached hill is found, or a series of them, presenting, as is sometimes the case, so smooth and regular an outline as to be compared to half a watermelon, and apparently located without any reference either in direction or character to the other elevations of the vicinity; and so also when the ground presents the appearance of a confused mass of broken bluffs, rocky faces and cleft surfaces thrown together without any apparent regard to order or regularity, it will be found that the general delineation, when followed far enough, will show that the contours, whatever may be their local complexity and irregularity of outline, follow the same general direction as the main ridges of the sheet. Along the intermediate shores, upon islands, or long arms running far out into the sea, where the sandy knolls, or dunes and ridges, shift or change their outline under the influence of wind and tide, an exception is found which calls for careful delineation, and the peculiar and striking character and forms of these should be portrayed with all possible exactness as an interesting and useful aid in the study of a correlative branch of geodesy.

To the meteorologist and to the physical geographer the careful mapping of dunes is valuable, for, however familiar the locality may be, no eye-view can discover those recurring features which are found in the map of an extended district.

If a sandy district is exposed to permanent or prevalent dry winds, travelling dunes will be found; these are distinguished from other hills by the contrast between the *fore slope* (on the lee side,) which is steep, and the near slope (on the windward side), which is gradual. Successive surveys on sandy coasts, where close attention has been given to the contours of the dunes, are of great value for comparison if every detail is carefully given. Even in places where the winds are uncertain, proper contouring discovers dunes which travel along the resultant of the forces, and in the direction of this resultant the great dip of the fore slope is found. For such dunes the several slopes for different points of the compass are equally interesting.

On exposed points, projecting far into the sea, peculiar dunes, called *galls*, are found. They are long, ridges of sand, broken by slough-ways. It has been observed that sometimes these slough-ways are parallel. Correct and well contoured topographical maps of the localities where they are found would aid much in a study of this interesting subject. Contours only would discover their order and exhibit the material system, which could not be done by a representation by hachures.

The delineation of bluffs along the shore should also, for like reasons, be carefully executed, and when it is possible, a representation of their slopes should be given. Bluffs, if worn by the waves, will usually exhibit three slopes: 1st, the caving slope at the top; 2d, the talus; 3d, the apron or flat, exposed wholly only at very low tides. The caving slope is sometimes perpendicular where tertiary country is being worn away—never where old dunes are yielding. The talus is usually of selected material—stones, perhaps. The talus and flat are generally wanting in bluffs worn by currents.

As has been said, in no branch of surveying does so much depend upon skill, combined with good judgment and experience, as the faithful representation of hills over an extended and diversified area, and long practice and close observation only can give facility and accuracy in its execution.

Various methods, more or less defective, in presenting a correct idea of elevations and depressions, have been contrived for topographical surveys; but the graphic representation of the successive gradations of level by means of horizontal lines, as at present employed in the Coast Survey, gives the nearest approximation to nature which has yet been devised, and when faithfully executed must letter

necessarily express very nearly, if not exactly, the shape and height desired.

Contours, or horizontal curves, are the outlines of horizontal sections of ground at different elevations, with designated equal intervals between their planes, delineated in their true positions relatively to each other and the rest of the map, and agreeably to the scale of the map itself; or, briefly, a contour is the curve produced by the intersection of a horizontal plane with the surface of the ground.

Perhaps contours may be described more simply as imaginary shore lines formed at stated or regular elevations, by the water which is supposed to rise successively to these elevations over the face of the country.

As each curve has equal vertical ordinates at all points, the elevation or profile of a hill, as well as a model in relief, can be constructed directly from the map when it is accurately executed on a large scale, without further field measurements.

A profile of a hill is the outline or trace formed with its surface by a vertical plane cutting the hill in any direction.

The annexed diagram, from actual survey (Plate No. 5), shows the profile, through the line A′ B′, of the hill H, as represented on a topographical map. The full parallel lines upon the profile represent successive heights, or sections of the hill of twenty feet, and the broken or intermediate lines, *x x x*, those of ten feet.

A reference to the letters upon the diagram is all that is necessary for a full understanding of the subject; *a* is the shore line or high water mark upon the map, *x x x* are the auxiliary ten-feet curves, *f′* the coincidence of curves upon the chart at the perpendicular face of the hill, *f* upon the section. This is the only case where contours of different heights run into each other upon a topographical plan. D′, D′ are depressions in the face of the hill represented on the profile by D, D ; *d′* is a barranca or dry broken gully, and *c′ c′* a water course.

It will be plain that if we were to suppose the water to rise to a height of twenty feet above the high-water line, or to *h* on the profile, the twenty-feet curve upon the map would then become the shore line and the depression D′ would become a pond of water ; and if the water were to rise to a height of thirty feet, the dotted broken line would form the shore line, and the knoll G would become an island.

Horizontal curves are drawn upon the map with the eye, after having obtained the heights, by means of which their positions are fixed, by the measurements of vertical angles with the arc of the alidade, or in detailed or special surveys, with the level. Where the slope is regular and tolerably steep, the tracing of them is attended with but little difficulty ; but where the rise is very gradual, giving large horizontal distances between the contours, even when the vision is unobstructed, or where the country is much broken or thrown into irregularly shaped knolls and depressions, presenting an intricate and confused variation of surface, the correct representation is, at times, very perplexing.

As in some instances, owing to the smallness of the angle to be measured, the vertical arc cannot be relied upon for close determination of heights, and it is evident that the nearer to a level a country is, the nearer it is necessary to obtain the exact elevation for the location of the contours, recourse to the level is indispensable. With the beginner the observations for elevation can hardly be too frequent, and he should constantly bear this in mind while at work, as well as the necessity for leaving frequent well-marked points of reference wherever it is practicable, or will serve a useful purpose.

When triangulation points are occupied, or positions are determined by the plane-table preliminary to the regular work,—in fact, whenever any station is occupied, its elevation should be taken, as well as the heights of such other prominent points or objects as may be commanded from it. Then in using these in working by resection, the topographer has necessarily as many points of reference for the determination of height as he has for determining his position.

It is well, also, to get observations for heights as often as possible upon or from the plane of reference or high-water mark, and advantage should be taken, whenever it presents itself, of observing from the shore line in wooded districts upon any detached openings which may present themselves, and also upon rocks or any other natural or artificial objects upon the sides of the surrounding hills.

Where the heights of certain points have been taken by the triangulation party, or a few prominent ones have been determined by the theodolite or level, they should be used as often as possible as points of reference.

When hills are inaccessible, the determination from accessible points of both the positions and heights of objects upon them, such as trees, rocks, stumps, etc., from which the positions and courses of the contours can be determined, should be sought for, and in thick forests the roads, paths, or the dry beds of streams may be found available for the use of either the vertical arc or level.

Under certain conditions, as those of densely wooded heights and vales, inaccessible, precipitous ledges and bluffs, etc., the operations of the surveyor are limited to an almost entire dependence upon the eye alone. This cannot be relied upon, of course, and should be avoided as much as possible.

It is customary to represent on the usual Coast Survey field sheets, heights of twenty feet; but occasionally, owing to marked accidents of ground, it is deemed advisable to insert an intermediate or auxiliary contour, the practicability of doing which, however, is sometimes interfered with by the small scale of the map, taken in connection with the exceeding steepness of the declivity, giving rise to a liability of coincidence and confusion. The capability of representation in this respect depends, then, very much on the general nature and abruptness of the hills, as, where very steep, the larger the scale of the map the greater the number of curves which can be shown, as in the French survey of Paris, where equidistant horizontal contours are drawn at every two metres of elevation.

Contours should be filled in from each station while carrying on the regular work, when it is possible to ascertain heights for that purpose, and in selecting positions for forward signals, and in prosecuting the work, reference should be had to the continuous and successive tracing of the contours on the map, both of those which are filled in *at* and those *from* the station, as this will generally prove an economy of time, and the work can be executed with more facility. When the operator is at a station whose elevation has been accurately determined, lines should be taken to objects of equal height in all directions, and marked to that effect, subsequent intersections giving their positions; this will be found of great assistance in running contours, and as checks. Care should be taken in sighting to distant objects to allow for the curvature of the earth.

With regard to the method of putting in contours from the base of the hill upward, or *vice versa*, opinions differ—some preferring one course, some another; but if the starting point be correct, it makes but little difference. Neither of these systems should be specially adopted, but the peculiarities and demands of the other topographical features should be considered, and the work should be done so as to carry on both simultaneously and to the best advantage. It frequently happens that a piece of work is done in one part of a sheet, and then it becomes necessary to work in another, in which case the first, where heights are well determined, serves a good purpose as a check in closing.

When, as often happens, the work has been carried on in a wooded country, in a place where observations have not been taken for a long time, the importance of coming out upon some fixed point is evident.

If this is impossible, as is sometimes the case, as in the filling in of the topography in dense woods, in a rolling country, where the operator is confined perforce to the roads, frequently with very short sights, and there is no check to come out upon; or when the work closes on the edge of the sheet, the use of the level in the hands of an aid, though consuming time, is indispensable.

The determination of the heights of artificial features, such as fence corners, houses, etc., as an assistance in contouring, should not be neglected.

When the contour runs very near any remarkable accident of ground, as a prominent spur or indentation, on general field maps of $\frac{1}{10000}$ scale, a slight deviation above or below its true plane is admissible, although it is preferable to represent it by the introduction of the auxiliary curves, as shown in the sketch.

It is very desirable that all features within the twenty feet curves, such as breaks in the ground, isolated boulders, rocks, etc., which cannot be legitimately represented by auxiliary curves, should be shown by hachures or conventional signs. When the rocks have a distinct stratification, or when cleft in certain directions, it should be indicated, if they or the scale of the map be sufficiently large to warrant it.

It may happen that at certain points certain small features, which are unimportant in themselves, may interfere with the development of the general form of the contours, or their introduction may tend to produce confusion ; these are best omitted, but this omission should be optional only with the practical hand. It is a dangerous precedent to give latitude in this respect to a beginner.

When there is an abrupt rise, as in low bluffs, railroad embankments, etc., not above ten feet in height, on a scale of $\frac{1}{10000}$, it should be marked by hachures always tapering downwards, and all hachures should, in their direction, follow the downward flow of water or alluvion.

Depressions of the ground in the midst of level tracts, or upon tops or slopes of hills, unless distinguished by ponds or marsh, should be marked with the letter D in red.

The distinct summits of hills should be marked in figures when they form characteristic or remarkable features of the country.

In measuring for heights or depressions with the alidade, the plane-table is carefully levelled and firmly clamped, the telescope is directed toward the point of observation, and moved until the cross-hairs are in the same vertical plane as the observed object. The telescope is then clamped by means of the screw at the top of the arms of the vertical arc, and the central cross-hairs, at or near their intersection, are brought to cover the observed point by means of the tangent screw attached to the graduated arc. The angle read, the distance between the occupied point and the observed point measured on the map, and the height is taken from the table, which is appended.

Example.—Observations for height at an occupied plane-table station.

STATIONS OBSERVED.	Observed Angles.	Distance in metres.	Relative height in feet of plane table station.	Height of observed station in feet	Height of plane-table in feet.	Corrected heights of ground in feet.
	° ′					
Shore signal (angle of depression)	1 57	1,756	+197.4	0	4	193.4
Smith's Hill (angle of elevation)..	0 02	940	− 2.0	201.3	4	195.3
Black Rock (angle of depression).	2 13	539	+ 68.7	126.9	4	191.6
Mean height of Station......	....	....	......	.....	...	193.4

Detail of use of table of heights.

SHORE SIGNAL:

1° 50′ for 1,700 metres	= 179.00 feet.
1° 50′ for 50 metres = 0.1 of 500 metres................	= 5.26 feet.
1° 50′ for 6 metres = 0.01 of 600 metres................	= .63 feet.
0° 07′ for 1,700 metres................................	= 12.10 feet.
0° 07′ for 50 metres................................	= .34 feet.
0° 07′: 6 6 metres................................	= .04 feet.
Total................................	197.37 feet.

In these observations three stations at least should be observed upon when practicable, and the mean adopted. Of an instrument at times unavoidably subject to such rough usage as the alidade, the adjustment of the vertical arc should be frequently examined.

A material advantage in the attachment of the longitudinal level to the alidade would be found in the facility by which the instrument could then be used as a level in following outlines of equal elevation, and would be particularly serviceable on gradually sloping ground.*

A formula for computation of heights, which may prove of service where no table of heights is at hand, is appended.

When, as is sometimes the case, a surveyor's level is employed, the determination of the position of the level pegs by the plane-table on the sheet is all that is necessary, and the contours can be readily traced.

Barometric heights are admissible for approximate contours in reconnaissance where only a general survey of hills or of ranges of hills is expected.

In using the aneroid barometer, in ordinary reconnaissance, it will suffice to allow ninety-two feet of elevation for every 0.1 of an inch fall of the index. This allowance is for a mean temperature of the two stations of 55° Fahrenheit, and will vary with the temperature.

Leslie's formula, simple and easily remembered, is a good approximation below 2,000 feet, and convenient for aneroid observations, viz. : $55,000 \times \frac{B-b}{B+b} =$ height in feet, B being the upper, and b the lower, reading of the aneroid. This is likewise for mean temperature of 55°.

A very convenient instrument for a tolerably close location of contours, when carefully employed, is Locke's hand-level, which can be readily carried in the pocket, it being requisite only to know the height of the eye from the ground, and for the observer to stand equally erect at all

---

* This has been attached to the recently made alidade.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

points of observation, or to hold the level at a constant height upon a measured staff.

Formula for determining heights by a vertical angle and distance.—The difference of level consists of two parts—that which rises from the angle of elevation above the horizontal plane of the station, and that which is due to the curvature of the earth. The former depends upon the angle and distance, the latter upon the distance and the earth's radius. If a' be the angle of elevation in minutes of arc, d the distance, h the height, then, as the tangent of 1′ is $\frac{1}{3437}$, we have for the first part $h = \frac{1}{3437} a' \times d$, if h and d are both expressed in the same units of length ; but if d is expressed in metres and h in feet, one metre being 3.28 feet, we get $h = \frac{1}{1048} a' d$. For the fraction $\frac{1}{1048}$ we may conveniently and with sufficient accuracy put $\frac{1}{1000}$ less $\frac{1}{20}$ of $\frac{1}{1000}$, and thus find the rule :—*Multiply the distance in metres with the number of minutes of arc, point off the thousandth part, and substract the twentieth part of the number thus obtained.* This will give the first portion of difference of height, whether elevation or depression.

The second term, depending on the curvature, varies as the square of the distance, and amounts to 0.22 foot in 1,000 metres, including the effect of ordinary refraction. As with the instruments under consideration extreme accuracy is not attainable, it is plain that for distances under 1,000 metres this term may be neglected. When the distance is greater we have the following rule :—*Take the thousandth part of the distance in metres, square the same, having regard to the first decimal figure, and multiply by* 0.22. This term is always positive ; if the first term be an elevation, it is increased ; if a depression, it is diminished by the second term.

Example.—Distance = 5,500 metres ; angle of elevation 36′.

$\frac{1}{1000} d \times a'$ =	198.000	$\frac{1}{1000} d$ =	5.5
subtract $\frac{1}{20}$	9.9	square =	30.2
		multiply by	0.22
first term	188.1		
second term	6.6	second term	6.64
sum	194.7 = difference of elevation in feet.		

The above formula is near enough for distances up to ten and fifteen miles, and will not differ by as much as a foot from the result of a rigorous formula ; in fact, it will keep within the limits of uncertainty of the refraction itself.

5500
36
33000
16500
198000

5.5
5.5
275
275
30.25
.22

6.6

194.7

1/32 3
a'

Table showing the height in feet corresponding to a given angle of elevation and a given distance in metres.

Metres.	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000
Angle.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1′	0.3	0.4	0.6	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.7	1.8	2.0	2.2	2.3	2.5	2.7	2.8
2	0.6	0.8	1.0	1.2	1.5	1.7	1.9	2.1	2.4	2.6	2.9	3.1	3.4	3.7	3.9	4.2	4.5	4.7
3	0.9	1.2	1.5	1.8	2.2	2.5	2.8	3.1	3.4	3.8	4.2	4.4	4.8	5.3	5.6	5.9	6.3	6.6
4	1.2	1.5	2.0	2.4	2.8	3.2	3.6	4.1	4.5	4.9	5.4	5.8	6.3	6.8	7.2	7.6	8.1	8.6
5	1.5	1.9	2.4	2.9	3.5	4.0	4.5	5.0	5.5	6.1	6.6	7.1	7.7	8.3	8.8	9.4	9.9	10.5
6	1.8	2.3	2.9	3.5	4.2	4.8	5.3	5.9	6.6	7.2	7.9	8.5	9.1	9.8	10.4	11.1	11.7	12.4
7	2.1	2.7	3.4	4.1	4.8	5.5	6.2	6.9	7.6	8.4	9.1	9.8	10.6	11.4	12.1	12.8	13.5	14.3
8	2.4	3.1	3.9	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.1	12.0	12.9	13.7	14.5	15.3	16.2
9	2.7	3.5	4.4	5.2	6.2	7.0	7.9	8.8	9.7	10.7	11.6	12.5	13.4	14.4	15.3	16.2	17.2	18.1
10	2.9	3.8	4.9	5.8	6.8	7.8	8.8	9.8	10.8	11.8	12.8	13.8	14.9	15.9	16.9	17.9	19.0	20.0
11	3.2	4.2	5.3	6.4	7.5	8.6	9.6	10.7	11.8	13.0	14.1	15.1	16.3	17.5	18.6	19.7	20.8	21.9
12	3.5	4.6	5.8	6.9	8.2	9.3	10.5	11.7	12.9	14.1	15.3	16.5	17.7	19.0	20.2	21.4	22.6	23.8
13	3.8	5.0	6.3	7.5	8.8	10.1	11.4	12.6	13.9	15.2	16.6	17.8	19.2	20.5	21.8	23.1	24.4	25.7
14	4.1	5.4	6.8	8.1	9.5	10.9	12.2	13.6	15.0	16.4	17.8	19.1	20.6	22.0	23.4	24.8	26.2	27.6
15	4.4	5.7	7.2	8.6	10.2	11.6	13.1	14.5	16.0	17.5	19.0	20.5	22.0	23.6	25.0	26.5	28.0	29.5
16	4.7	6.1	7.7	9.2	10.8	12.4	13.9	15.5	17.1	18.7	20.3	21.8	23.5	25.1	26.7	28.2	29.9	31.4
17	4.9	6.5	8.2	9.8	11.5	13.1	14.8	16.5	18.1	19.8	21.5	23.1	24.9	26.6	28.3	30.0	31.7	33.4
18	5.2	6.9	8.7	10.4	12.2	13.9	15.7	17.4	19.2	21.0	22.8	24.5	26.3	28.2	29.9	31.7	33.5	35.3
19	5.5	7.3	9.1	10.9	12.8	14.7	16.5	18.4	20.2	22.1	24.0	25.8	27.7	29.7	31.5	33.4	35.3	37.2
20	5.8	7.7	9.6	11.5	13.5	15.4	17.4	19.3	21.3	23.3	25.2	27.2	29.2	31.2	33.2	35.1	37.1	39.1

Table showing the height in feet, etc.—Continued.

Metres.	300	400	500	600	700	800	900	1,000	1,100	1,200	1 300	1,400	1,500	1,600	1,700	1,800	1,900	2,000
Angle.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
21′	6.1	8.0	10.1	12.1	14 2	16.2	18.2	20.3	22.3	24.4	26 5	28.5	30.6	32.7	34.8	36.8	38.9	41.0
22	6.4	8.4	10.6	12.6	14.9	17.0	19.1	21.2	23.4	25.5	27.7	29.8	32.0	34.3	36.4	38.5	40.7	42.9
23	6.7	8.8	11.1	13.2	15.5	17.7	20.0	22.2	24.4	26.7	29.0	31.2	33.5	35.8	38.0	40.3	42.5	44.8
24	6.9	9.2	11 5	13.8	16.2	18.5	20.8	23.1	25.5	27.8	30.2	32.5	34.9	37.3	39.6	42.0	44.3	46.7
25	7.2	9.6	12.0	14.4	16.9	19.3	21 7	24.1	26.5	29.0	31.4	33.8	36.3	38.8	41.3	43.7	46.2	48.6
26	7.5	9.9	12.5	14.9	17.5	20.0	22.5	25.0	27.6	30.1	32.7	35.2	37.8	40.4	42.9	45.4	48.0	50.5
27	7.8	10.3	13.0	15.5	18.2	20.8	23.4	26.0	28.6	31.3	33.9	36.5	39.2	41.9	44.5	47.1	49.8	52.4
28	8.1	10.7	13.4	16.1	18 9	21.5	24.2	26.9	29.7	32.4	35.2	37.8	40.6	43.4	46.1	48.8	51.6	54.3
29	8.4	11.1	13 9	16.7	19.5	22.3	25.1	27.9	30.7	33.6	36.4	39.2	42.1	45 0	47.8	50.6	53.4	56.2
30	8.7	11 5	14.4	17.2	20.2	23.1	26.0	28.9	31.8	34.7	37.6	40.5	43 5	46.5	49.4	52.3	55.2	58.2
40	11.5	15.3	19.2	22.9	26 9	30.7	34.6	38.4	42.3	46.1	50.0	53.9	57.8	61.7	65.6	69.4	73.3	77.3
50	14.4	19 1	23.9	28.7	33.5	38.3	43.2	47.9	52.7	57.6	62.4	67.2	72.1	77.0	81.8	86.6	91.5	96.3
1° 00	17.2	22.9	28.7	34.4	40.2	46.0	51.7	57.5	63.3	69.0	74.8	80.6	86.4	92.3	98.0	104	110	115
1 10	20.1	26.7	33.5	40.1	46.9	53.6	60.3	67.0	73 8	80.5	87.2	93.9	100.7	107.5	114.3	121	128	134
1 20	23.0	30.5	38.3	45.8	53.6	61.2	69.0	76.6	84.2	91.9	99.6	107.3	115.1	123	131	138	146	154
1 30	25.8	34 4	43.0	51.6	60.3	69.0	77.7	86.1	94.7	103.4	112.0	120.7	130	138	147	155	164	173
1 40	28.7	38.2	47.8	57.3	66.9	76.6	86.3	95.6	105.2	115	124	134	144	153	163	173	182	192
1 50	31.6	42.0	52.6	63.0	73.6	84.2	94.9	105.2	115.7	126	137	147	158	169	179	190	200	211
2 00	34.4	45.8	57.4	68.9	80	92	103	115	126	138	149	161	172	184	195	207	218	230
2 30	43.0	57.3	71 7	86.0	100	115	129	144	158	172	186	201	215	230	244	259	273	287
3 00	51.6	68.8	86.2	103.2	120	138	155	172	190	207	224	241	259	276	293	310	328	345
3 30	60.2	80.4	100.5	120 5	141	161	181	201	221	241	261	281	302	322	342	362	382	402
4 00	68.9	91.8	114 8	137.7	161	184	207	230	253	276	299	322	345	368	391	414	437	460

CHAIN.—However frequent may be the number of bases furnished by the secondary triangulation, and however serviceable as a substitute in the measurement of distances the telemeter may have proved itself, we cannot entirely dispense with the chain; and as the circumstances under which its use is rendered necessary are mentioned elsewhere, it is only requisite to give a short description of the one employed in the Coast Survey. It is twenty metres long, and consists of that number of pieces of stout iron or steel wire, each piece or link being exactly one metre in length, and connected at either end with the next by being bent into an eye, through which passes a ring connecting it with the eye of the following link. For convenience of carriage these links are subdivided into lesser ones in some chains; but the advantage resulting from this is questionable, as the rupture almost invariably occurs at the joints, and multiplying them of course increases the liability to breakage; besides, the "kinking," or tendency to overlap or double, is also increased in proportion to the number of joints. On the other hand, it may be said that the bending of the links is decreased in proportion to their shortness.

At each extremity of the chain is a large ring, which slips over a staff held in the hand of the chain-man, and rests upon a projecting rim at the pointed iron shoe at its base. The centres of these rings at the ends of the extended chain are the extremities of a line of twenty metres, and the points at which the pins should be inserted during the chaining.

As the strain constantly exerted upon the chain to straighten it must finally lengthen it by the "giving" of the rings, or as it may at times be shortened when the links are bent by being drawn over fences, rocks, or other unyielding obstructions, it is well to test it occasionally by a careful verification. Grave difficulties have arisen where dependence has been placed entirely upon long chained distances from a neglect of this source of error.

Adjusting screws are attached to the terminal rings of some of the chains, by which any error of length can be corrected. If a line of great length has been measured by an incorrect chain, the error in the line should be ascertained from the known error of the chain, and the plotted line corrected accordingly.

Each chain is accompanied by the usual number of pins, and a spring wire triangle for carrying them. The pins are also made of stout wire, about 18 inches long, pointed at one end, and bent into a ring at the other. It is well to attach white cotton or red flannel rags to the ring of each pin, that the rear chain-man may distinguish it more readily in high grass, marsh, bushes, etc., and also at the ends of the five, ten, and fifteen metre links of the chain, for facility in counting. These rags should be changed as they become soiled.

Care should be exercised in the selection of intelligent chain-men, since it is often upon the precision of their work that the correctness of the survey in a great measure depends, and it is not always convenient or practicable for an assistant to accompany them. The better man of the two should be placed at the rear end of the chain, as he is the most responsible, and the forward man should implicitly obey his instructions. In all important places, however, such as closely settled districts, villages, and towns, in the measurement of base lines or distances upon which anything of mark may depend, an aid should go with the chain and check the records of the men.

When chaining is done in connection with the plane-table and the station is reached, the chain should be drawn sufficiently beyond and clear of the table to be out of the way, so that if more chaining is contemplated it does not have to pass between the legs of the instrument.

With the class of young men usually employed as chainmen in the Coast Survey parties, it has been found safe and serviceable, after a little experience, in the absence of an aid, to have the rear man keep a chain-book, in which he notes all the crossings of high and low water, intersections of brooks, fences, roads, etc., with rectangular offsets to all reasonably accessible points on either hand, including bottoms and tops of slopes, the record of tallies, and such other matters as may be needed, and may serve to assure accuracy in case of unfavorable intersections.

It is the habit with some, in obtaining short distances to comparatively unimportant objects, to resort to pacing, and practice enables one to ascertain thus the distances sufficiently close for plotting on a $\frac{1}{10000}$ scale; but these distances should never be great, and the topographer should be well assured of the accuracy of the pace. The use of the telemeter, however, may take the place of this method.

All distances to objects on either side of the chain line should be taken by offsets at right angles to it, and the book of the aid should, as far as possible, be so held that the line drawn as his guide in sketching should be in the same direction as the chained line itself, the better to enable him to draw his objects in their true relative positions.

Where great accuracy is necessary the length of a gradual slope may be measured and the angle of inclination taken with the vertical arc, with repetitions, and the meas-

$(y - x) = y - y \cos \delta = y(1 - \cos \delta)$

$(1 - \cos \delta) = 2 \sin^2 \frac{\delta}{2} \quad y - x = 2y \sin^2 \frac{\delta}{2}$

urement made reduced to the horizon by means of the following formula:

Let y be the length of the line measured upon the slope, δ its angle of inclination, and x its length reduced to the horizon; then—

$$x = y \cos \delta.$$

The excess of y over x may be computed by the formula,

$$y - x = 2y \sin^2 \frac{\delta}{2}$$

On very large scales, when parts of a metre are perceptible, Payne's tape, consisting of a narrow steel ribbon, which can be marked for minute distances, has been employed to advantage. It is convenient, also, for rapid reconnoissance in military surveys, and has been used under fire almost at double quick. Under these circumstances three men were employed, the usual back and forward chain-man, with another to stand by the pins when stuck until about half the chain had passed, then, by pointing to indicate the position of the pin to the back chain-man, and run forward in time to find, without difficulty, the forward pin, and also to change the pins at each tally. This tape will not stand as rough handling as the chain, and cannot be repaired in the field when broken, while the latter can lose one or more of its links and still be of service. The easy obliteration of the marks measured upon it by attrition has also been found a source of difficulty. All things considered, however, it is a very useful, compact, and handy instrument.

Many instances showing the remarkable accuracy with which the chain can be employed with the plane-table might be given from the reports of the officers of the Coast Survey; but it must be remembered that it is only to be used when other means are impracticable.

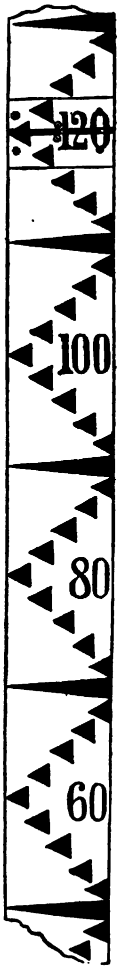
LIBRARY OF THE UNIVERSITY OF CALIFORNIA

TELEMETER.—In consequence of some of the disadvantages resulting from the employment of the chain, among which are the necessity of frequent dependence for correct distances upon the chain-men, the number of persons required, the time consumed in its management, and the impediments to its use found in the features of some sections of country, another instrument, styled the telemeter, has been advantageously introduced in the topographical work of the Coast Survey.

It appears that instruments of this class were at first generally regarded by scientific men as merely ingenious inventions, and not as valuable in most respects as the ordinary method of chaining, the filling in of details forming a principal exception. From the experience of its use by the officers of the Coast Survey, however, it has been satisfactorily ascertained that the rapidity with which the details of a survey can be determined and sketched, the smaller number of men necessary to be employed, and that whatever errors may occur rest with the observer only, and the facility in using it in places where the use of the chain is impracticable, or at best difficult, render the telemeter a very important acquisition. It is not considered that it will ever entirely supersede the chain as a measuring instrument, but it is undoubtedly a facile and useful substitute under certain conditions.

The telemeter, as used in the Coast Survey, is simply a scale of equal parts, painted upon a wooden rod about 10 feet long, 5 inches wide, and 1¼ inch thick, so graduated that the number of divisions upon it, as seen between the upper and lower horizontal wires of the telescope, is equal to the number of units in the distance between the observer's eye and the rod held at right angles to the line of sight.

In all cases the telemeter should be graduated experimentally for the particular instrument and eye of the observer who has it in use.



The horizontal wires in the diaphragm of the telescope should be accurately adjusted, and the divisions of the telemeter made to correspond in length with the distance included between the upper and lower wires of the telescope at a carefully measured distance, and then divided into as many equal parts as there are units in the distance measured.

For convenience of transportation it can be hinged in the middle, and secured on the side when in use, by a sliding bolt; and as it is necessary, when observed upon, that it should be held accurately at right angles to the line of sight, a small brass movable bar, with sights or a groove upon its upper edge, should be fixed upon the side of the rod at a convenient height for the eye of the rodman, and which, when in position, will be perpendicular to the plane of the telemeter and directly in the line of sight of the telescope.

The correctness of the telemeter depends upon the closeness of the reading, and the accuracy with which the rod is held perpendicularly to the line of sight.

With ordinary care an error of reading should not occur even at the greatest distance denoted on the rod. With the observations carefully made, and the reading of the rod reduced to a horizontal plane, the greatest distance given by it—as usually divided—can be relied on as practically correct. There is no sensible error at any distance greater than 20 metres and less than 260, and, generally speaking, the telescopes of the Coast-Survey alidades have not sufficient reading power beyond 400 metres, but it will generally be safe to rely upon it for any distance from 15 to 300 metres, beyond which it cannot be read with accuracy for use in constructing a map on a scale of $\frac{1}{10000}$.

The telemeter has been recommended for use in a great variety of cases where it becomes necessary to determine distances, in such close filling in as the corners of streets, wharves, etc., determination of all classes of detail, in traverse, shore line, and even the establishment of positions, but in the latter it is safe only to depend upon good intersections. It has been employed, however, in all manner of detail, and is preferred by some to the chain, in all cases save in compactly built streets, and on long lines, where the distances are so great that the telescope will not admit of the accurate reading of the rod. It is maintained by some that where only a single point is to be seen, positions can be readily and accurately determined.

For the reduction of the hypothenuse to the base, the following table is given.

Table for reduction of hypothenuse to base.

ANGLE.	HYPOTHENUSE.				
	100 Metres.	200 Metres.	300 Metres.	400 Metres.	500 Metres.
5°	99.62	199.24	298.86	398.48	498.10
10°	98.48	196.96	295.44	393.92	492.40
15°	96.59	193.19	289.78	386.37	482.96
20°	93.97	187.94	281.91	375.88	469.85
25°	90.63	181.26	271.89	362.52	453.15
30°	86.60	173.21	259.81	346.41	433.01
35°	81.92	163.83	245.75	327.66	409.58
40°	76.60	153.21	229.81	306.42	383.02
45°	70.71	141.42	212.13	282.84	353.55

Reconnoissance.—The term reconnoissance, as applied to topography, is a somewhat indefinite one, or rather it might be said it is very comprehensive. When there is any deviation from the closest attainable accuracy in a finished plane-table sheet, it becomes, strictly speaking, a reconnoissance map, and the rudest sketch of a country in which the features are delineated in rough approximation, which for certain temporary purposes is all that is needed, is likewise so called, so that in executing this kind of work with the plane-table there is much left to the judgment of the topographer. The amount of accuracy and closeness of detail required depends solely upon the object for which the survey is undertaken, and the time and expense allotted to its completion. It is always best, however, to strive for the greatest precision which the circumstances will allow, particularly as the sheet may at some future time become available for other objects than that originally intended.

To the practical surveyor it is unnecessary to give any rules for his guidance, as his knowledge of the plane-table and of the requirements of the special work which he is called upon to perform will enable him to execute it promptly and satisfactorily. To the beginner, however, a few words on this subject, together with a statement of some of the results of the work accomplished by the Coast Survey officers, may not come amiss.

The recent war has shown in a forcible manner how little accurate information there was with respect to the topography of the interior of many of our Middle and Southern States, and the want of a sufficient number of topographers in the regular army was supplied, in answer to the calls of the War Department and various generals in the field, from the Coast Survey; and in almost every field of operations from the commencement of the war to its close, the plane-table was used.

Until this time very little was known, save in theory, of the value of the plane-table as a reconnoitring instrument, and it is the testimony of all the officers of these parties, as the result of their labors, that for rapidity and accuracy in the execution of military reconnoissance it is more effective than any other instrument.

The usual system adopted, in default of triangulation, was the measurement of a base with an ordinary chain and triangulating with the plane-table.

In detailed surveys for the army, where a topographer averages about a square mile a day, a chained base of from one-half to three-quarters of a mile for the survey of an area of twenty-five square miles, is found sufficient.

At Chattanooga, from two different bases of about half a mile each, plotted on separate sheets, and measured once carefully with the common 20-metres chain, the same chain being used for both measurements, after considerable intermediate plane-table triangulation, carried on by two officers, two objects were determined two and a half miles apart, common to both sheets, which were on a scale of $\frac{1}{10000}$, and the discrepancy was but about 15 metres. Many other points of junction indicated this to be the maximum error. In this case the leaves were mostly off the trees, and the hills afforded good points. The sheets covered about twenty square miles each. At Nashville there was a discrepancy of about 10 metres in two miles. This would not do, of course, in finished work, but it is very close under the circumstances.

At other times, when the character of the country or the pressure of time did not admit of the measurement of a preliminary base and topographical triangulation, the work was commenced by starting from a single point, and prosecuted by linear measurement with the chain, intersections from the ends of the chained lines being taken to determine objects, which, as the work progressed, could also be used as checks upon the chaining. Where circumstances permitted, an occasional return with the chain to a back point, either to close a series of lines upon it or to start afresh, was resorted to. This work was generally carried on over roads, and the interior filled in by sketching and intersections, as far as practicable. Some of the tests in this latter work, where the operations of two officers joined, were remarkably close.

It is estimated that with the usual number of hands and a good sketcher for aid, in a county of average variety of detail, in which all the houses, prominent barns and outbuildings, streams, roads, general outline of woods, and approximate curves are to be shown, on a scale of $\frac{1}{10000}$, an area of between two and three square miles can be filled in daily, with not only sufficient accuracy for military purposes, but so that an accustomed eye with "the map in hand would not discover any marked discrepancy."

This rapidity of work, however, could not be expected in or near towns or populous districts. It is doubtful if the average work would reach more than one-half this amount.

In some thickly wooded sections, and where time is limited, it has been found advisable to run the main roads with the plane-table, and fill in with the compass, which is more rapid but less accurate than where the entire work is done with the plane-table alone. The usual method employed, where these instruments were combined, was as follows:—Where the army was stationary, or moving leisurely, one main road was run with the plane-table, the operator being accompanied by assistants well practised in the use of the compass. Upon arriving at any important road or water-course, an assistant was sent to the right and left, starting from a plane-table point, determined by the chaining, and running as far as was requisite, and then returning to the main road again to repeat the operation, the compass notes, of course, being kept in a book prepared for the purpose. Prominent points determined by the plane-table were used as checks in the compass work. The intervening topography, where no compass or plane-table work had been done, was sketched in by the chief of the party, in which accurate pacing became of great service.

Office Work.—All the drawing of the topographical features of a survey upon the chart should be pencilled in the field, while they are still under the eye. Sketching and plotting in the office from notes, unless the country be near at hand for ready reference in case of doubt or a defective sketch, is objectionable. Where this is unavoidable the sketch should be transferred to the sheet as soon as possible after having been taken, while it is fresh in the mind of the person by whom it was made, and by whom, also, if possible, it should be plotted. Days which, from inclemency of the weather, are unfavorable for out-of-door work, should be allotted to this purpose, and advantage should be taken of them, also, for retouching any details of the sheet which may have become indistinct, as it is very important that they should not be left indefinite or become obliterated; for when the inking is done, as it generally is, at a distance from the field of operations, the necessity for this care is obvious. Nos. 4 and 5 pencils are good for this purpose, for which very hard or very soft and black pencils are equally unsuited.

In the inking of a topographical sheet three requisites to its proper appearance when finished should be borne in mind :—clearness, neatness, and uniformity.

The lines and objects should be clean and sharply defined, nothing being left obscure or doubtful ; the paper should be kept unsoiled, and erasures avoided as far as possible, and the style and strength of the drawing should be the same throughout. It is an important matter that an easy and natural appearance should be given to the map, for, as before remarked, a mere rigid adherence to conventional signs is not all that is necessary ; while there should be no deviation in this respect, at the same time the draughtsman should strive to *represent the country*. There is a great difference with regard to this among topographers. Two perfectly correct charts of the same section of ground, executed by different persons, may be inked, and while one will have a stiff and ungraceful look, the other will appear artistic and natural, giving at once the impression of a sincere representation of the country surveyed.

Office work should not be commenced until the topography is entirely completed, as no inked or partially inked chart should ever be used in the field. Sometimes, for the special examination of old work, or for the insertion of some recent artificial or natural changes, this becomes necessary. There is always a risk of injuring an inked map by exposure to the weather or by using it upon a plane-table.

The inking should commence with the shore-lines, high and low water. The high-water, or shore-line proper, should, in all cases, be full and black, the heaviest lines on the sheet, and in this, as in all the rest of the ink-work, the lines of the survey should be strictly adhered to.

The topography as drawn in the field is supposed to be correct when the chart is finished, and no office amendments or changes are admissible. The low-water line is next drawn, not so full as the former, but clear, black, and uniform, consisting of a dotted line for sand and mud, and the conventional sign where it is formed by shells, rocks, or coral reefs.

Grass upon flats, or shoals covered at high tide, have no distinct continuous line to mark their limits, each being represented in its proper form and within its area by its conventional sign only, but the shape should be well and correctly defined. All objects between high and low water, covered at full tide, should be represented less boldly than the rest of the map, but not faintly or indefinitely.

The roads should next be inked, plainly and evenly, with parallel sides, except where the survey shows a deviation from the general width. Where a road is fenced the fence should be shown by the usual sign, and where there is no enclosure a dotted line should indicate the road-side, and then should follow the fences and houses. In drawing the latter, care must be taken that the corners and angles exhibit a sharp, clear outline, which adds much to the appearance of the map.

The general skeleton of the survey being now completed, the contours are drawn with a bold, uniform, plain, red line, without break, over all the other work, following accurately the full range of level of each of the contours on the sheet.

After this comes the general filling in, by conventional signs, of sand, marsh, grass, cultivation, orchards, rocks, hachures, etc. Some practice is needed to execute the sand-work regularly and neatly. It should never be hurriedly done, though, of course, rapidity in this respect follows practice. The lines representing marsh, and the delineation of grass on the fast land, should always run in the same direction over the whole sheet, and be parallel to the top of the sheet and the title. The appended drawing (Plate No. 6) gives the conventional signs as adopted by and now used in the Coast Survey.

The most difficult part of the inking for a beginner is the lettering, which now follows, and for which samples are given (Plate No. 6). It is expected that every topographer shall have learned to draw sufficiently well to ink his sheet in a clear and distinct manner, and letter it with some regard to neatness and graphic effect, as the appearance of an otherwise well-inked sheet is sometimes marred by careless or indifferent lettering.

The location of the names upon the sheet should be such as to not cover or obliterate any detail or feature of the survey, and the letters should be put in neatly and gracefully, and in point of size and form according to the specimens furnished. The title should finally follow, with such notes as may be necessary to explain any peculiarity of the sheet or survey. This title and lettering should, as far as practicable, be so placed that when the sheet is held with the top (usually the north or east end of the map) from you it can be easily read; in other words, as nearly parallel to the top or upper end of the sheet as the nature of the work will admit. All names well established and recognized in a neighborhood, both general and local, should be collected during the survey, and their correct orthography ascertained, and, in case of any doubtful or disputed orthography, a report should be given of any traditions or any authorities which may bear upon the subject. No illuminated or German text, old English, or what is known as "fancy printing," should be indulged in, a strict adherence to simplicity being maintained.

The minutes of the parallels of latitude and meridians of longitude should be marked in figures at the upper and right-hand ends, respectively; the degrees, on the centre parallel and centre meridian only.

Where the buoys are determined by the topographer, and their names, colors, numbers, or kind are known, they should be lettered upon the map.

The triangulation points should also be lettered, first being surrounded by a small circle. The magnetic meridian should be drawn with a half fleur-de-lis at its head, and the true meridian, where no projection is used, with a full one.

Francis' Lowell Hydraulics.

Third Edition.

4to. Cloth. $15.00.

LOWELL HYDRAULIC EXPERIMENTS — being a Selection from Experiments on Hydraulic Motors, on the Flow of Water over Weirs, and in Open Canals of Uniform Rectangular Section, made at Lowell, Mass. By J. B. FRANCIS, Civil Engineer. Third edition, revised and enlarged, including many New Experiments on Gauging Water in Open Canals, and on the Flow through Submerged Orifices and Diverging Tubes. With 23 copperplates, beautifully engraved, and about 100 new pages of text.

The work is divided into parts. PART I., on hydraulic motors, includes ninety-two experiments on an improved Fourneyron Turbine Water-Wheel, of about two hundred horse-power, with rules and tables for the construction of similar motors; thirteen experiments on a model of a centre-vent water-wheel of the most simple design, and thirty-nine experiments on a centre-vent water-wheel of about two hundred and thirty horse-power.

PART II. includes seventy-four experiments made for the purpose of determining the form of the formula for computing the flow of water over weirs; nine experiments on the effect of back-water on the flow over weirs; eighty-eight experiments made for the purpose of determining the formula for computing the flow over weirs of regular or standard forms, with several tables of comparisons of the new formula with the results obtained by former experimenters; five experiments on the flow over a dam in which the crest was of the same form as that built by the Essex Company across the Merrimack River at Lawrence, Massachusetts; twenty-one experiments on the effect of observing the depths of water on a weir at different distances from the weir; an extensive series of experiments made for the purpose of determining rules for gauging streams of water in open canals, with tables for facilitating the same; and one hundred and one experiments on the discharge of water through submerged orifices and diverging tubes, the whole being fully illustrated by twenty-three double plates engraved on copper.

In 1855 the proprietors of the Locks and Canals on Merrimack River consented to the publication of the first edition of this work, which contained a selection of the most important hydraulic experiments made at Lowell up to that time. In this edition the principal hydraulic experiments made there, subsequent to 1855, have been added, including the important series above mentioned, for determining rules for the gauging the flow of water in open canals, and the interesting series on the flow through a submerged Venturi's tube, in which a larger flow was obtained than any we find recorded.

Williamson's Meteorological Tables.

4to. Flexible Cloth. $2.50.

PRACTICAL TABLES IN METEOROLOGY AND HYPSOMETRY, in connection with the use of the Barometer. By Col. R. S. WILLIAMSON, U. S. A.

Merrill's Iron Truss Bridges.

Third Edition.

4to. Cloth. $5.00.

IRON TRUSS BRIDGES FOR RAILROADS. The Method of Calculating Strains in Trusses, with a careful comparison of the most prominent Trusses, in reference to economy in combination, etc., etc. By Brevet Colonel WILLIAM E. MERRILL, U.S.A., Major Corps of Engineers. Nine lithographed plates of illustrations.

"The work before us is an attempt to give a basis for sound reform in this feature of railroad engineering, by throwing 'additional light upon the method of calculating the maxima strains that can come upon any part of a bridge truss, and upon the manner of proportioning each part, so that it shall be as strong relatively to its own strains as any other part, and so that the entire bridge may be strong enough to sustain several times as great strains as the greatest that can come upon it in actual use.' "—*Scientific American.*

"The author has presented his views in a clear and intelligent manner, and the ingenuity displayed in coloring the figures so as to present certain facts to the eye forms no inappreciable part of the merits of the work. The reduction of the 'formulæ for obtaining the strength, volume, and weight of a cast-iron pillar under a strain of compression,' will be very acceptable to those who have occasion hereafter to make investigations involving these conditions. As a whole, the work has been well done."—*Railroad Gazette, Chicago.*

Allan's Theory of Arches.

18mo. Boards. 50 cts.

THEORY OF ARCHES. By Prof. W. ALLAN, formerly of Washington and Lee University. Illustrated.

"This little volume is an amplification and explanation of Prof. Rankine's chapters on this subject."

Shreve on Bridges and Roofs.

8vo, 87 wood-cut illustrations. Cloth. $5.00.

A TREATISE ON THE STRENGTH OF BRIDGES AND ROOFS—comprising the determination of Algebraic formulas for Strains in Horizontal, Inclined or Rafter, Triangular, Bowstring, Lenticular and other Trusses, from fixed and moving loads, with practical applications and examples, for the use of Students and Engineers. By Samuel H. Shreve, A.M., Civil Engineer.

"On the whole, Mr. Shreve has produced a book which is the simplest, clearest, and at the same time, the most systematic and with the best mathematical reasoning of any work upon the same subject in the language."—*Railroad Gazette.*

"From the unusually clear language in which Mr. Shreve has given every statement, the student will have but himself to blame if he does not become thorough master of the subject."—*London Mining Journal.*

"Mr. Shreve has produced a work that must always take high rank as a text-book, * * * and no Bridge Engineer should be without it, as a valuable work of reference, and one that will frequently assist him out of difficulties."—*Franklin Institute Journal.*

The Kansas City Bridge.

4to. Cloth. $6.00

WITH AN ACCOUNT OF THE REGIMEN OF THE MISSOURI RIVER, and a description of the Methods used for Founding in that River. By O. Chanute, Chief Engineer, and George Morison, Assistant Engineer. Illustrated with five lithographic views and twelve plates of plans.

Illustrations.

Views.—View of the Kansas City Bridge, August 2, 1869. Lowering Caisson No. 1 into position. Caisson for Pier No. 4 brought into position. View of Foundation Works, Pier No. 4. Pier No. 1.

Plates.—I. Map showing location of Bridge. II. Water Record—Cross Section of River—Profile of Crossing—Pontoon Protection. III. Water Deadener—Caisson No. 2—Foundation Works, Pier No. 3. IV. Foundation Works, Pier No. 4. V. Foundation Works, Pier No. 4. VI. Caisson No. 5—Sheet Piling at Pier No. 6—Details of Dredges—Pile Shoe—Beton Box. VII. Masonry—Draw Protection—False Works between Piers 3 and 4. VIII. Floating Derricks. IX. General Elevation—176 feet span. X. 248 feet span. XI. Plans of Draw. XII. Strain Diagrams.

Clarke's Quincy Bridge.

4to. Cloth. $7.50.

DESCRIPTION OF THE IRON RAILWAY Bridge across the Mississippi River at Quincy, Illinois. By THOMAS CURTIS CLARKE, Chief Engineer. Illustrated with twenty-one lithographed plans.

Barba on the Use of Steel.

12mo. Illustrated. Cloth. $1.50.

THE USE OF STEEL IN CONSTRUCTION. Method of Working, Applying, and Testing Plates and Bars. By J. BARBA, Chief Naval Constructor. Translated from the French, with a Preface, by A. L. HOLLEY, P.B.

Whipple on Bridge Building.

8vo, Illustrated. Cloth. $4.00.

AN ELEMENTARY AND PRACTICAL TREATISE ON BRIDGE BUILDING. An enlarged and improved edition of the Author's original work. By S. WHIPPLE, C. E., Inventor of the Whipple Bridges, &c. Second Edition.

The design has been to develop from Fundamental Principles a system easy of comprehension, and such as to enable the attentive reader and student to judge understandingly for himself, as to the relative merits of different plans and combinations, and to adopt for use such as may be most suitable for the cases he may have to deal with.

It is hoped the work may prove an appropriate Text-Book upon the subject treated of, for the Engineering Student, and a useful manual for the Practicing Engineer and Bridge Builder.

Stoney on Strains.

New and Revised Edition, with numerous illustrations.

Royal 8vo, 664 pp. Cloth. $12.50.

THE THEORY OF STRAINS IN GIRDERS and Similar Structures, with Observations on the Application of Theory to Practice, and Tables of Strength and other Properties of Materials. By BINDON B. STONEY, B. A.

Roebling's Bridges.

Imperial folio. Cloth. $25.00.

LONG AND SHORT SPAN RAILWAY BRIDGES. By JOHN A. ROEBLING, C. E. Illustrated with large copperplate engravings of plans and views.

List of Plates

1. Parabolic Truss Railway Bridge. 2, 3, 4, 5, 6. Details of Parabolic Truss, with centre span 500 feet in the clear. 7. Plan and View of a Bridge over the Mississippi River, at St. Louis, for railway and common travel. 8, 9, 10, 11, 12. Details and View of St. Louis Bridge. 13. Railroad Bridge over the Ohio.

Diedrichs' Theory of Strains.

8vo. Cloth. $5.00.

A Compendium for the Calculation and Construction of Bridges, Roofs, and Cranes, with the Application of Trigonometrical Notes. Containing the most comprehensive information in regard to the Resulting Strains for a permanent Load, as also for a combined (Permanent and Rolling) Load. In two sections adapted to the requirements of the present time. By JOHN DIEDRICHS. Illustrated by numerous plates and diagrams.

"The want of a compact, universal and popular treatise on the Construction of Roofs and Bridges—especially one treating of the influence of a variable load—and the unsatisfactory essays of different authors on the subject, induced me to prepare this work."

Jacob on Retaining Walls.

18mo. Boards. 50 cts.

PRACTICAL DESIGNING OF RETAINING WALLS. By ARTHUR JACOB, A. B.

Campin on Iron Roofs.

Large 8vo. Cloth. $2.00.

ON THE CONSTRUCTION OF IRON ROOFS. A Theoretical and Practical Treatise. By FRANCIS CAMPIN. With wood-cuts and plates of Roofs lately executed.

"The mathematical formulas are of an elementary kind, and the process admits of an easy extension so as to embrace the prominent varieties of iron truss bridges. The treatise, though of a practical scientific character, may be easily mastered by any one familiar with elementary mechanics and plane trigonometry."

Holley's Railway Practice.

1 vol. folio. Cloth. $12.00.

AMERICAN AND EUROPEAN RAILWAY PRACTICE, in the Economical Generation of Steam, including the materials and construction of Coal-burning Boilers, Combustion, the Variable Blast, Vaporization, Circulation, Super-heating, Supplying and Heating Feed-water, &c., and the adaptation of Wood and Coke-burning Engines to Coal-burning; and in Permanent Way, including Road-bed, Sleepers, Rails, Joint Fastenings, Street Railways, &c., &c. By ALEXANDER L. HOLLEY, B. P. With 77 lithographed plates.

"This is an elaborate treatise by one of our ablest civil engineers, on the construction and use of locomotives, with a few chapters on the building of Railroads. * * * All these subjects are treated by the author, who is a first-class railroad engineer, in both an intelligent and intelligible manner. The facts and ideas are well arranged, and presented in a clear and simple style, accompanied by beautiful engravings, and we presume the work will be regarded as indispensable by all who are interested in a knowledge of the construction of railroads and rolling stock, or the working of locomotives."—*Scientific American.*

Henrici's Skeleton Structures.

8vo. Cloth. $1.50.

SKELETON STRUCTURES, especially in their Application to the building of Steel and Iron Bridges. By OLAUS HENRICI. With folding plates and diagrams.

By presenting these general examinations on Skeleton Structures, with particular application for Suspended Bridges, to Engineers, I venture to express the hope that they will receive these theoretical results with some confidence, even although an opportunity is wanting to compare them with practical results. O. H.

Useful Information for Railway Men.

Pocket form. Morocco, gilt, $2.00.

Compiled by W. G. HAMILTON, Engineer. Sixth edition, revised and enlarged. 570 pages.

"It embodies many valuable formulæ and recipes useful for railway men, and, indeed, for almost every class of persons in the world. The 'information' comprises some valuable formulæ and rules for the construction of boilers and engines, masonry, properties of steel and iron, and the strength of materials generally."—*Railroad Gazette, Chicago.*

The Mechanic's Friend.

12mo. Cloth. 300 Illustrations. $1.50.

THE MECHANIC'S FRIEND : A Collection of Receipts and Practical Suggestions, Relating to Aquaria — Bronzing — Cements — Drawing — Dyes — Electricity — Gilding — Glass-Working — Glues — Horology — Lacquers — Locomotives — Magnetism — Metal-Working — Modelling — Photography — Pyrotechny — Railways — Solders — Steam-Engine — Telegraphy — Taxidermy — Varnishes — Waterproofing — and Miscellaneous Tools, Instruments, Machines, and Processes connected with the Chemical and Mechanical Arts. By WILLIAM E. AXON, M.R.S.L.

Kirkwood on Filtration.

4to. Cloth. $15.00.

REPORT ON THE FILTRATION OF RIVER WATERS, for the Supply of Cities, as practised in Europe, made to the Board of Water Commissioners of the City of St. Louis. By JAMES P. KIRKWOOD. Illustrated by 30 double-plate engravings.

CONTENTS.—Report on Filtration—London Works, General—Chelsea Water Works and Filters—Lambeth Water Works and Filters—Southwark and Vauxhall Water Works and Filters—Grand Junction Water Works and Filters—West Middlesex Water Works and Filters—New River Water Works and Filters—East London Water Works and Filters—Leicester Water Works and Filters—York Water Works and Filters—Liverpool Water Works and Filters—Edinburgh Water Works and Filters—Dublin Water Works and Filters—Perth Water Works and Filtering Gallery—Berlin Water Works and Filters—Hamburg Water Works and Reservoirs—Altona Water Works and Filters—Tours Water Works and Filtering Canal—Angers Water Works and Filtering Galleries—Nantes Water Works and Filters—Lyons Water Works and Filtering Galleries—Toulouse Water Works and Filtering Galleries—Marseilles Water Works and Filters—Genoa Water Works and Filtering Galleries—Leghorn Water Works and Cisterns—Wakefield Water Works and Filters—Appendix.

Tunner on Roll-Turning.

1 vol. 8vo. and 1 vol. plates. $10.00.

A TREATISE ON ROLL-TURNING FOR THE MANUFACTURE OF IRON. By PETER TUNNER. Translated and adapted. By JOHN B. PEARSE, of the Pennsylvania Steel Works. With numerous wood-cuts, 8vo., together with a folio atlas of 10 lithographed plates of Rolls, Measurements, &c.

"We commend this book as a clear, elaborate, and practical treatise upon the department of iron manufacturing operations to which it is devoted. The writer states in his preface, that for twenty-five years he has felt the necessity of such a work, and has evidently brought to its preparation the fruits of experience, a painstaking regard for accuracy of statement, and a desire to furnish information in a style readily understood. The book should be in the hands of every one interested, either in the general practice of mechanical engineering, or the special branch of manufacturing operations to which the work relates."—*American Artisan.*

Jacob on Storage Reservoirs.

18mo. Boards. 50 cts.

THE DESIGNING AND CONSTRUCTION OF STORAGE RESERVOIRS. By ARTHUR JACOB, B. A. With tables and wood-cuts representing sections, etc.

Hewson on Embankments.

8vo. Cloth. $2.00.

PRINCIPLES AND PRACTICE OF EMBANKING LANDS from River Floods, as applied to the Levees of the Mississippi. By WILLIAM HEWSON, Civil Engineer.

"This is a valuable treatise on the principles and practice of embanking lands from river floods, as applied to the Levees of the Mississippi, by a highly intelligent and experienced engineer. The author says it is a first attempt to reduce to order and to rule the design, execution, and measurement of the Levees of the Mississippi. It is a most useful and needed contribution to scientific literature.—*Philadelphia Evening Journal.*

Grüner on Steel.

8vo. Cloth. $3.50.

THE MANUFACTURE OF STEEL. By M. L. GRUNER, translated from the French. By Lenox Smith, A. M., E. M., with an appendix on the Bessemer Process in the United States, by the translator. Illustrated by lithographed drawings and wood-cuts.

"The purpose of the work is to present a careful, elaborate, and at the same time practical examination into the physical properties of steel, as well as a description of the new processes and mechanical appliances for its manufacture. The information which it contains, gathered from many trustworthy sources, will be found of much value to the American steel manufacturer, who may thus acquaint himself with the results of careful and elaborate experiments in other countries, and better prepare himself for successful competition in this important industry with foreign makers. The fact that this volume is from the pen of one of the ablest metallurgists of the present day, cannot fail, we think, to secure for it a favorable consideration.—*Iron Age.*

Bauerman on Iron.

12mo. Cloth. $2.00.

TREATISE ON THE METALLURGY OF IRON. Containing outlines of the History of Iron Manufacture, methods of Assay, and analysis of Iron Ores, processes of manufacture of Iron and Steel, etc., etc. By H. BAUERMAN. First American edition. Revised and enlarged, with an appendix on the Martin Process for making Steel, from the report of Abram S. Hewitt. Illustrated with numerous wood engravings.

"This is an important addition to the stock of technical works published in this country. It embodies the latest facts, discoveries, and processes connected with the manufacture of iron and steel, and should be in the hands of every person interested in the subject, as well as in all technical and scientific libraries."—*Scientific American.*

Link and Valve Motions, by W. S. Auchincloss.

Sixth Edition. 8vo. Cloth. $3.00.

APPLICATION OF THE SLIDE VALVE and Link Motion to Stationary, Portable, Locomotive and Marine Engines, with new and simple methods for proportioning the parts. By WILLIAM S. AUCHINCLOSS, Civil and Mechanical Engineer. Designed as a hand-book for Mechanical Engineers, Master Mechanics, Draughtsmen and Students of Steam Engineering. All dimensions of the valve are found with the greatest ease by means of a Printed Scale, and proportions of the link determined *without* the assistance of a model. Illustrated by 37 wood-cuts and 21 lithographic plates, together with a copperplate engraving of the Travel Scale.

All the matters we have mentioned are treated with a clearness and absence of unnecessary verbiage which renders the work a peculiarly valuable one. The Travel Scale only requires to be known to be appreciated. Mr. A. writes so ably on his subject, we wish he had written more. *London Engineering.*

We have never opened a work relating to steam which seemed to us better calculated to give an intelligent mind a clear understanding of the department it discusses.—*Scientific American.*

Slide Valve by Eccentrics, by Prof. C. W. MacCord.

4to. Illustrated. Cloth, $4.00.

A PRACTICAL TREATISE ON THE SLIDE VALVE BY ECCENTRICS, examining by methods, the action of the Eccentric upon the Slide Valve, and explaining the practical processes of laying out the movements, adapting the valve for its various duties in the steam-engine. For the use of Engineers, Draughtsmen, Machinists, and Students of valve motions in general. By C. W. MacCord, A. M., Professor of Mechanical Drawing, Stevens' Institute of Technology, Hoboken, N J.

Stillman's Steam-Engine Indicator.

12mo. Cloth. $1.00.

THE STEAM-ENGINE INDICATOR, and the Improved Manometer Steam and Vacuum Gauges; their utility and application By Paul Stillman. New edition.

Bacon's Steam-Engine Indicator.

12mo. Cloth. $1.00. Mor. $1.50.

A TREATISE ON THE RICHARDS STEAM-ENGINE INDICATOR, with directions for its use. By Charles T. Porter. Revised, with notes and large additions as developed by American Practice, with an Appendix containing useful formulæ and rules for Engineers. By F. W. Bacon, M. E., Member of the American Society of Civil Engineers. Illustrated. Second Edition

In this work, Mr. Porter's book has been taken as the basis, but Mr. Bacon has adapted it to American Practice, and has conferred a great boon on American Engineers.—*Artisan.*

Steam Boiler Explosions.

18mo. Boards. 50 cts.

STEAM BOILER EXPLOSIONS. By Zerah Colburn.

"It is full of practical information, and serves to show in a most marked manner how very little one's knowledge upon the subject has advanced during the past ten years."—*N. Y. Times.*

Gillmore's Limes and Cements.

Fifth Edition. Revised and Enlarged.

8vo. Cloth. $4.00.

PRACTICAL TREATISE ON LIMES, HYDRAULIC CEMENTS, AND MORTARS. Papers on Practical Engineering, U. S. Engineer Department, No. 9, containing Reports of numerous experiments conducted in New York City, during the years 1858 to 1861, inclusive. By Q. A. GILLMORE, Lt.-Col. U. S. Corps of Engineers, Brevet Major-General U. S. Army. With numerous illustrations.

"This work contains a record of certain experiments and researches made under the authority of the Engineer Bureau of the War Department from 1858 to 1861, upon the various hydraulic cements of the United States, and the materials for their manufacture. The experiments were carefully made, and are well reported and compiled.'—*Journal Franklin Institute.*

Gillmore's Coignet Beton.

8vo. Cloth. $2.50.

COIGNET BETON AND OTHER ARTIFICIAL STONE. By Q. A. GILLMORE, Lt.-Col. U. S Corps of Engineers, Brevet Major-General U. S. Army. 9 Plates, Views, etc.

This work describes with considerable minuteness of detail the several kinds of artificial stone in most general use in Europe and now beginning to be introduced in the United States, discusses their properties, relative merits, and cost, and describes the materials of which they are composed. . . . . The subject is one of special and growing interest, and we commend the work, embodying as it does the matured opinions of an experienced engineer and expert.

Gillmore on Roads.

12mo. Cloth. In Press.

A PRACTICAL TREATISE ON THE CONSTRUCTION OF ROADS, STREETS, AND PAVEMENTS. By Q. A. GILLMORE, Lt.-Col. U. S. Corps of Engineers, Brevet Major-General U. S. Army.

Williamson on the Barometer.

4to. Cloth, $15.00.

ON THE USE OF THE BAROMETER ON SURVEYS AND RECONNAISSANCES. Part I. Meteorology in its Connection with Hypsometry. Part II. Barometric Hypsometry. By R. S. WILLIAMSON, Bvt. Lieut.-Col. U. S. A., Major Corps of Engineers. With Illustrative Tables and Engravings. Paper No. 15, Professional Papers, Corps of Engineers.

"SAN FRANCISCO, CAL., *Feb.* 27, 1867.

"Gen. A. A. HUMPHREYS, Chief of Engineers, U. S. Army:

"GENERAL,—I have the honor to submit to you, in the following pages, the results of my investigations in meteorology and hypsometry, made with the view of ascertaining how far the barometer can be used as a reliable instrument for determining altitudes on extended lines of survey and reconnaissances. These investigations have occupied the leisure permitted me from my professional duties during the last ten years, and I hope the results will be deemed of sufficient value to have a place assigned them among the printed professional papers of the United States Corps of Engineers.

"Very respectfully, your obedient servant,

"R. S. WILLIAMSON,

"Bvt. Lt.-Col. U. S. A., Major Corps of U. S. Engineers."

Von Cotta's Ore Deposits.

8vo. Cloth. $4.00.

TREATISE ON ORE DEPOSITS. By BERNHARD VON COTTA, Professor of Geology in the Royal School of Mines, Freidberg, Saxony. Translated from the second German edition, by FREDERICK PRIME, Jr., Mining Engineer, and revised by the author, with numerous illustrations.

"Prof. Von Cotta of the Freiberg School of Mines, is the author of the best modern treatise on ore deposits, and we are heartily glad that this admirable work has been translated and published in this country. The translator, Mr. Frederick Prime, Jr., a graduate of Freiberg, has had in his work the great advantage of a revision by the author himself, who declares in a prefatory note that this may be considered as a new edition (the third) of his own book.

"It is a timely and welcome contribution to the literature of mining in this country, and we are grateful to the translator for his enterprise and good judgment in undertaking its preparation; while we recognize with equal cordiality the liberality of the author in granting both permission and assistance."—*Extract from Review in Engineering and Mining Journal.*

Plattner's Blow-Pipe Analysis.

Second edition. Revised. 8vo. Cloth. $7.50.

PLATTNER'S MANUAL OF QUALITATIVE AND QUANTITATIVE ANALYSIS WITH THE BLOW-PIPE. From the last German edition Revised and enlarged. By Prof. TH. RICHTER, of the Royal Saxon Mining Academy. Translated by Prof. H. B. CORNWALL, Assistant in the Columbia School of Mines, New York; assisted by JOHN H. CASWELL. Illustrated with eighty-seven wood-cuts and one Lithographic Plate. 560 pages.

" Plattner's celebrated work has long been recognized as the only complete book on Blow-Pipe Analysis. The fourth German edition, edited by Prof. Richter, fully sustains the reputation which the earlier editions acquired during the lifetime of the author, and it is a source of great satisfaction to us to know that Prof. Richter has co-operated with the translator in issuing the American edition of the work, which is in fact a fifth edition of the original work, being far more complete than the last German edition."—*Silliman's Journal.*

There is nothing so complete to be found in the English language. Plattner's book is not a mere pocket edition; it is intended as a comprehensive guide to all that is at present known on the blow-pipe, and as such is really indispensable to teachers and advanced pupils.

" Mr. Cornwall's edition is something more than a translation, as it contains many corrections, emendations and additions not to be found in the original. It is a decided improvement on the work in its German dress."—*Journal of Applied Chemistry.*

Egleston's Mineralogy.

8vo. Illustrated with 34 Lithographic Plates. Cloth. $4.50.

LECTURES ON DESCRIPTIVE MINERALOGY, Delivered at the School of Mines, Columbia College. BY PROFESSOR T. EGLESTON.

These lectures are what their title indicates, the lectures on Mineralogy delivered at the School of Mines of Columbia College. They have been printed for the students, in order that more time might be given to the various methods of examining and determining minerals. The second part has only been printed. The first part, comprising crystallography and physical mineralogy, will be printed at some future time.

Pynchon's Chemical Physics.

New Edition. Revised and Enlarged.

Crown 8vo. Cloth. $3.00.

INTRODUCTION TO CHEMICAL PHYSICS, Designed for the Use of Academies, Colleges, and High Schools. Illustrated with numerous engravings, and containing copious experiments with directions for preparing them. By THOMAS RUGGLES PYNCHON, M.A., Professor of Chemistry and the Natural Sciences, Trinity College, Hartford.

Hitherto, no work suitable for general use, treating of all these subjects within the limits of a single volume, could be found; consequently the attention they have received has not been at all proportionate to their importance. It is believed that a book containing so much valuable information within so small a compass, cannot fail to meet with a ready sale among all intelligent persons, while Professional men, Physicians, Medical Students, Photographers, Telegraphers, Engineers, and Artisans generally, will find it specially valuable, if not nearly indispensable, as a book of reference.

"We strongly recommend this able treatise to our readers as the first work ever published on the subject free from perplexing technicalities. In style it is pure, in description graphic, and its typographical appearance is artistic. It is altogether a most excellent work."—*Eclectic Medical Journal.*

"It treats fully of Photography, Telegraphy, Steam Engines, and the various applications of Electricity. In short, it is a carefully prepared volume, abreast with the latest scientific discoveries and inventions."—*Hartford Courant.*

Plympton's Blow-Pipe Analysis.

12mo. Cloth. $1 50.

THE BLOW-PIPE: A Guide to Its Use in the Determination of Salts and Minerals. Compiled from various sources, by GEORGE W. PLYMPTON, C.E., A.M., Professor of Physical Science in the Polytechnic Institute, Brooklyn, N. Y.

"This manual probably has no superior in the English language as a text-book for beginners, or as a guide to the student working without a teacher. To the latter many illustrations of the utensils and apparatus required in using the blow-pipe, as well as the fully illustrated description of the blow-pipe flame, will be especially serviceable."—*New York Teacher.*

Dubois' Graphical Statics.

8vo. 60 Illustrations. Cloth. $2.00.

THE NEW METHOD OF GRAPHICAL STATICS. By A. J. DUBOIS, C.E., Ph.D.

Gases in Coal Mines

18mo. Boards. 50 cts.

A PRACTICAL TREATISE ON THE GASES MET WITH IN COAL MINES. By the late J. J. ATKINSON, Government Inspector of Mines for the County of Durham, England.

Watt's Dictionary of Chemistry.

Supplementary Volume.

8vo. Cloth. $9.00.

This volume brings the Record of Chemical Discovery down to the end of the year 1869, including also several additions to, and corrections of, former results which have appeared in 1870 and 1871.

⁂ Complete Sets of the Work, New and Revised edition, including above supplement. 6 vols. 8vo. Cloth. $62.00.

Rammelsberg's Chemical Analysis.

8vo. Cloth. $2.25.

GUIDE TO A COURSE OF QUANTITATIVE CHEMICAL ANALYSIS, ESPECIALLY OF MINERALS AND FURNACE PRODUCTS. Illustrated by Examples. By C. F. RAMMELSBERG. Translated by J. TOWLER, M.D.

This work has been translated, and is now published expressly for those students in chemistry whose time and other studies in colleges do not permit them to enter upon the more elaborate and expensive treatises of Fresenius and others. It is the condensed labor of a master in chemistry and of a practical analyst.

Eliot and Storer's Qualitative Chemical Analysis.

New Edition, Revised.

12mo. Illustrated. Cloth. $1.50.

A COMPENDIOUS MANUAL OF QUALITATIVE CHEMICAL ANALYSIS. By Charles W. Eliot and Frank H. Storer. Revised with the Coöperation of the Authors, by William Ripley Nichols, Professor of Chemistry in the Massachusetts Institute of Technology.

"This Manual has great merits as a practical introduction to the science and the art of which it treats. It contains enough of the theory and practice of qualitative analysis, "in the wet way," to bring out all the reasoning involved in the science, and to present clearly to the student the most approved methods of the art. It is specially adapted for exercises and experiments in the laboratory; and yet its classifications and manner of treatment are so systematic and logical throughout, as to adapt it in a high degree to that higher class of students generally who desire an accurate knowledge of the practical methods of arriving at scientific facts."—*Lutheran Observer.*

"We wish every academical class in the land could have the benefit of the fifty exercises of two hours each necessary to master this book. Chemistry would cease to be a mere matter of memory, and become a pleasant experimental and intellectual recreation. We heartily commend this little volume to the notice of those teachers who believe in using the sciences as means of mental discipline."—*College Courant.*

Craig's Decimal System.

Square 32mo. Limp. 50c.

WEIGHTS AND MEASURES. An Account of the Decimal System, with Tables of Conversion for Commercial and Scientific Uses. By B. F. Craig, M. D.

"The most lucid, accurate, and useful of all the hand-books on this subject that we have yet seen. It gives forty-seven tables of comparison between the English and French denominations of length, area, capacity, weight, and the Centigrade and Fahrenheit thermometers, with clear instructions how to use them; and to this practical portion, which helps to make the transition as easy as possible, is prefixed a scientific explanation of the errors in the metric system, and how they may be corrected in the laboratory."—*Nation.*

Nugent on Optics.

12mo. Cloth. $2.00

TREATISE ON OPTICS; or, Light and Sight, theoretically and practically treated; with the application to Fine Art and Industrial Pursuits. By E. NUGENT. With one hundred and three illustrations.

"This book is of a practical rather than a theoretical kind, and is designed to afford accurate and complete information to all interested in applications of the science."—*Round Table.*

Barnard's Metric System.

8vo. Brown cloth. $3.00.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES. An Address delivered before the Convocation of the University of the State of New York, at Albany, August, 1871. By FREDERICK A. P. BARNARD, President of Columbia College, New York City. Second edition from the Revised edition printed for the Trustees of Columbia College. Tinted paper.

"It is the best summary of the arguments in favor of the metric weights and measures with which we are acquainted, not only because it contains in small space the leading facts of the case, but because it puts the advocacy of that system on the only tenable grounds, namely, the great convenience of a decimal notation of weight and measure as well as money, the value of international uniformity in the matter, and the fact that this metric system is adopted and in general use by the majority of civilized nations."—*The Nation.*

Butler on Ventilation.

18mo. Boards. 50 cts.

VENTILATION OF BUILDINGS. By W. F. BUTLER. Illustrated.

"As death by insensible suffocation is one of the prominent causes which swell our bills of mortality, we commend this book to the attention of philanthropists as well as to architects."—*Boston Globe.*

Harrison's Mechanic's Tool-Book.

12mo. Cloth. $1.50.

MECHANIC'S TOOL BOOK, with practical rules and suggestions, for the use of Machinists, Iron Workers, and others. By W. B. Harrison, Associate Editor of the "American Artisan." Illustrated with 44 engravings.

"This work is specially adapted to meet the wants of Machinists and workers in iron generally. It is made up of the work-day experience of an intelligent and ingenious mechanic, who had the faculty of adapting tools to various purposes. The practicability of his plans and suggestions are made apparent even to the unpractised eye by a series of well-executed wood engravings."—*Philadelphia Inquirer.*

Pope's Modern Practice of the Electric Telegraph.

Ninth Edition. 8vo. Cloth $2.00.

A Hand-book for Electricians and Operators. By Frank L. Pope. Seventh edition. Revised and enlarged, and fully illustrated.

Extract from Letter of Prof. Morse.

"I have had time only cursorily to examine its contents, but this examination has resulted in great gratification, especially at the fairness and unprejudiced tone of your whole work.

"Your illustrated diagrams are admirable and beautifully executed.

"I think all your instructions in the use of the telegraph apparatus judicious and correct, and I most cordially wish you success."

Extract from Letter of Prof. G. W. Hough, of the Dudley Observatory.

"There is no other work of this kind in the English language that contains in so small a compass so much practical information in the application of galvanic electricity to telegraphy. It should be in the hands of every one interested in telegraphy, or the use of Batteries for other purposes."

Morse's Telegraphic Apparatus.

Illustrated. 8vo. Cloth. $2.00.

EXAMINATION OF THE TELEGRAPHIC APPARATUS AND THE PROCESSES IN TELEGAPHY. By Samuel F. B. Morse, LL.D., United States Commissioner Paris Universal Exposition, 1867.

Sabine's History of the Telegraph.

12mo. Cloth. $1.25.

HISTORY AND PROGRESS OF THE ELECTRIC TELEGRAPH, with Descriptions of some of the Apparatus. By ROBERT SABINE, C. E. Second edition, with additions.

CONTENTS.—I. Early Observations of Electrical Phenomena. II. Telegraphs by Frictional Electricity. III. Telegraphs by Voltaic Electricity. IV. Telegraphs by Electro-Magnetism and Magneto-Electricity. V. Telegraphs now in use. VI. Overhead Lines. VII. Submarine Telegraph Lines. VIII. Underground Telegraphs. IX. Atmospheric Electricity.

Haskins' Galvanometer.

Pocket form. Illustrated. Morocco tucks. $2.00.

THE GALVANOMETER, AND ITS USES; a Manual for Electricians and Students. By C. H. HASKINS.

"We hope this excellent little work will meet with the sale its merits entitle it to. To every telegrapher who owns, or uses a Galvanometer, or ever expects to, it will be quite indispensable."—*The Telegrapher.*

Culley's Hand-Book of Telegraphy.

8vo. Cloth. $5.00.

A HAND-BOOK OF PRACTICAL TELEGRAPHY. By R. S. CULLEY, Engineer to the Electric and International Telegraph Company. Fifth edition, revised and enlarged.

Foster's Submarine Blasting.

4to. Cloth. $3.50.

SUBMARINE BLASTING in Boston Harbor, Massachusetts—Removal of Tower and Corwin Rocks. By JOHN G. FOSTER, Lieutenant-Colonel of Engineers, and Brevet Major-General, U. S. Army. Illustrated with seven plates.

LIST OF PLATES.—1. Sketch of the Narrows, Boston Harbor. 2. Townsend's Submarine Drilling Machine, and Working Vessel attending. 3. Submarine Drilling Machine employed. 4. Details of Drilling Machine employed. 5. Cartridges and Tamping used. 6. Fuses and Insulated Wires used. 7. Portable Friction Battery used.

Barnes' Submarine Warfare.

8vo. Cloth. $5.00.

SUBMARINE WARFARE, DEFENSIVE AND OFFENSIVE. Comprising a full and complete History of the Invention of the Torpedo, its employment in War and results of its use. Descriptions of the various forms of Torpedoes, Submarine Batteries and Torpedo Boats actually used in War. Methods of Ignition by Machinery, Contact Fuzes, and Electricity, and a full account of experiments made to determine the Explosive Force of Gunpowder under Water. Also a discussion of the Offensive Torpedo system, its effect upon Iron-Clad Ship systems, and influence upon Future Naval Wars. By Lieut.-Commander JOHN S. BARNES, U. S. N. With twenty lithographic plates and many wood-cuts.

"A book important to military men, and especially so to engineers and artillerists. It consists of an examination of the various offensive and defensive engines that have been contrived for submarine hostilities, including a discussion of the torpedo system, its effects upon iron-clad ship-systems, and its probable influence upon future naval wars. Plates of a valuable character accompany the treatise, which affords a useful history of the momentous subject it discusses. A great deal of useful information is collected in its pages, especially concerning the inventions of SCHOLL and VERDU, and of JONES' and HUNT'S batteries, as well as of other similar machines, and the use in submarine operations of gun-cotton and nitro-glycerine."—*N. Y. Times.*

Randall's Quartz Operator's Hand-Book.

12mo. Cloth. $2.00.

QUARTZ OPERATOR'S HAND-BOOK. By P. M. RANDALL. New edition, revised and enlarged. Fully illustrated.

The object of this work has been to present a clear and comprehensive exposition of mineral veins, and the means and modes chiefly employed for the mining and working of their ores—more especially those containing gold and silver.

McCulloch's Theory of Heat.

8vo. Cloth. In Press.

AN ELEMENTARY TREATISE ON THE MECHANICAL THEORY OF HEAT, AND ITS APPLICATION TO AIR AND STEAM ENGINES. By Prof. R. S. McCulloch.

Benét's Chronoscope.

Second Edition.

Illustrated. 4to. Cloth. $3.00.

ELECTRO-BALLISTIC MACHINES, and the Schultz Chronoscope. By Lieutenant-Colonel S. V. Benét, Captain of Ordnance, U. S. Army.

Contents.—1. Ballistic Pendulum. 2. Gun Pendulum. 3. Use of Electricity. 4. Navez' Machine. 5. Vignotti's Machine, with Plates. 6. Benton's Electro-Ballistic Pendulum, with Plates. 7. Leur's Tro-Pendulum Machine 8. Schultz's Chronoscope, with two Plates.

Michaelis' Chronograph.

4to. Illustrated. Cloth. $3.00.

THE LE BOULENGÉ CHRONOGRAPH. With three lithographed folding plates of illustrations. By Brevet Captain O E. Michaelis, First Lieutenant Ordnance Corps, U. S. Army.

"The excellent monograph of Captain Michaelis enters minutely into the details of construction and management, and gives tables of the times of flight calculated upon a given fall of the chronometer for all distances. Captain Michaelis has done good service in presenting this work to his brother officers, describing, as it does, an instrument which bids fair to be in constant use in our future ballistic experiments."—*Army and Navy Journal.*

Silversmith's Hand-Book.

Fourth Edition.

Illustrated. 12mo. Cloth. $3.00.

A PRACTICAL HAND-BOOK FOR MINERS, Metallurgists, and Assayers, comprising the most recent improvements in the disintegration, amalgamation, smelting, and parting of the Precious Ores, with a Comprehensive Digest of the Mining Laws. Greatly augmented, revised, and corrected. By JULIUS SILVERSMITH. Fourth edition. Profusely illustrated. 1 vol. 12mo. Cloth. $3.00.

One of the most important features of this work is that in which the metallurgy of the precious metals is treated of. In it the author has endeavored to embody all the processes for the reduction and manipulation of the precious ores heretofore successfully employed in Germany, England, Mexico, and the United States, together with such as have been more recently invented, and not yet fully tested—all of which are profusely illustrated and easy of comprehension.

Simms' Levelling.

8vo. Cloth. $2.50.

A TREATISE ON THE PRINCIPLES AND PRACTICE OF LEVELLING, showing its application to purposes of Railway Engineering and the Construction of Roads, &c. By FREDERICK W. SIMMS, C. E. From the fifth London edition, revised and corrected, with the addition of Mr. Law's Practical Examples for Setting Out Railway Curves. Illustrated with three lithographic plates and numerous wood-cuts.

"One of the most important text-books for the general surveyor, and there is scarcely a question connected with levelling for which a solution would be sought, but that would be satisfactorily answered by consulting this volume." —*Mining Journal.*

"The text-book on levelling in most of our engineering schools and colleges."—*Engineers.*

"The publishers have rendered a substantial service to the profession, especially to the younger members, by bringing out the present edition of Mr. Simms' useful work."—*Engineering.*

Stuart's Successful Engineer.

18mo. Boards. 50 cents.

HOW TO BECOME A SUCCESSFUL ENGINEER: Being Hints to Youths intending to adopt the Profession. By BERNARD STUART, Engineer. Sixth Edition.

"A valuable little book of sound, sensible advice to young men who wish to rise in the most important of the professions."—*Scientific American.*

Stuart's Naval Dry Docks.

Twenty-four engravings on steel.

Fourth Edition.

4to. Cloth. $6.00.

THE NAVAL DRY DOCKS OF THE UNITED STATES. By CHARLES B. STUART. Engineer in Chief of the United States Navy.

List of Illustrations.

Pumping Engine and Pumps—Plan of Dry Dock and Pump-Well—Sections of Dry Dock—Engine House—Iron Floating Gate—Details of Floating Gate—Iron Turning Gate—Plan of Turning Gate—Culvert Gate—Filling Culvert Gates—Engine Bed—Plate, Pumps, and Culvert—Engine House Roof—Floating Sectional Dock—Details of Section, and Plan of Turn-Tables—Plan of Basin and Marine Railways—Plan of Sliding Frame, and Elevation of Pumps—Hydraulic Cylinder—Plan of Gearing for Pumps and End Floats—Perspective View of Dock, Basin, and Railway—Plan of Basin of Portsmouth Dry Dock—Floating Balance Dock—Elevation of Trusses and the Machinery—Perspective View of Balance Dry Dock

Free Hand Drawing.

Profusely Illustrated. 18mo. Boards. 50 cents.

A GUIDE TO ORNAMENTAL, Figure, and Landscape Drawing. By an Art Student.

CONTENTS.—Materials employed in Drawing, and how to use them—On Lines and how to Draw them—On Shading—Concerning lines and shading, with applications of them to simple elementary subjects—Sketches from Nature.

Minifie's Mechanical Drawing.

Ninth Edition.

Royal 8vo. Cloth. $4.00.

A TEXT-BOOK OF GEOMETRICAL DRAWING for the use of Mechanics and Schools, in which the Definitions and Rules of Geometry are familiarly explained; the Practical Problems are arranged, from the most simple to the more complex, and in their description technicalities are avoided as much as possible. With illustrations for Drawing Plans, Sections, and Elevations of Buildings and Machinery; an Introduction to Isometrical Drawing, and an Essay on Linear Perspective and Shadows. Illustrated with over 200 diagrams engraved on steel. By Wm. Minifie, Architect. Eighth Edition. With an Appendix on the Theory and Application of Colors.

"It is the best work on Drawing that we have ever seen, and is especially a text-book of Geometrical Drawing for the use of Mechanics and Schools. No young Mechanic, such as a Machinist, Engineer, Cabinet-Maker, Millwright, or Carpenter, should be without it."—*Scientific American.*

" One of the most comprehensive works of the kind ever published, and cannot but possess great value to builders. The style is at once elegant and substantial."—*Pennsylvania Inquirer.*

"Whatever is said is rendered perfectly intelligible by remarkably well-executed diagrams on steel, leaving nothing for mere vague supposition; and the addition of an introduction to isometrical drawing, linear perspective, and the projection of shadows, winding up with a useful index to technical terms." —*Glasgow Mechanics' Journal.*

☞ The British Government has authorized the use of this book in their schools of art at Somerset House, London, and throughout the kingdom.

Minifie's Geometrical Drawing.

New Edition. Enlarged.

12mo. Cloth. $2.00.

GEOMETRICAL DRAWING. Abridged from the octavo edition, for the use of Schools. Illustrated with 48 steel plates. New edition, enlarged.

"It is well adapted as a text-book of drawing to be used in our High Schools and Academies where this useful branch of the fine arts has been hitherto too much neglected."—*Boston Journal.*

Bell on Iron Smelting.

8vo. Cloth. $6.00.

CHEMICAL PHENOMENA OF IRON SMELTING. An experimental and practical examination of the circumstances which determine the capacity of the Blast Furnace, the Temperature of the Air, and the Proper Condition of the Materials to be operated upon. By I. LOWTHIAN BELL.

Battershall's Legal Chemistry.

Illustrated. 12mo. Cloth. In press.

LEGAL CHEMISTRY. A Guide to the detection of Poisons, Falsification of Writings, Adulteration of Alimentary and Pharmaceutical Substances; Analysis of Ashes, and Examination of Hair, Coins, Fire-Arms, and Stains, as applied to Chemical Jurisprudence. For the use of Chemists, Physicians, Lawyers, Pharmacists, and Experts. Translated with additions, including a list of books and memoirs on Toxicology, etc., from the French of A. NAQUET. By J. P. BATTERSHALL, Ph.D., with a Preface by C. F. CHANDLER, Ph.D., M.D., LL.D.

King's Notes on Steam.

Nineteenth Edition.

8vo. Cloth. $2.00.

LESSONS AND PRACTICAL NOTES ON STEAM, the Steam-Engine, Propellers, &c., &c., for Young Engineers, Students, and others. By the late W. R. KING, U. S. N. Revised by Chief-Engineer J. W. KING, U. S. Navy.

"This is one of the best, because eminently plain and practical treatises on the Steam Engine ever published."—*Philadelphia Press.*

This is the thirteenth edition of a valuable work of the late W. H. King, U. S. N. It contains lessons and practical notes on Steam and the Steam Engine, Propellers, etc. It is calculated to be of great use to young marine engineers, students, and others. The text is illustrated and explained by numerous diagrams and representations of machinery.—*Boston Daily Advertiser.*

Text-book at the U. S. Naval Academy, Annapolis.

Burgh's Modern Marine Engineering.

One thick 4to vol. Cloth. $25.00. Half morocco. $30.00.

MODERN MARINE ENGINEERING, applied to Paddle and Screw Propulsion. Consisting of 36 Colored Plates, 259 Practical Wood-cut Illustrations, and 403 pages of Descriptive Matter, the whole being an exposition of the present practice of the following firms: Messrs. J. Penn & Sons; Messrs. Maudslay, Sons & Field; Messrs. James Watt & Co.; Messrs. J. & G. Rennie; Messrs. R. Napier & Sons; Messrs. J. & W. Dudgeon; Messrs. Ravenhill & Hodgson; Messrs. Humphreys & Tenant; Mr. J. T. Spencer, and Messrs. Forrester & Co. By N. P. BURGH, Engineer.

PRINCIPAL CONTENTS.—General Arrangements of Engines, 11 examples —General Arrangement of Boilers, 14 examples — General Arrangement of Superheaters, 11 examples—Details of Oscillating Paddle Engines, 34 examples—Condensers for Screw Engines, both Injection and Surface, 20 examples—Details of Screw Engines, 20 examples—Cylinders and Details of Screw Engines, 21 examples—Slide Valves and Details, 7 examples—Slide Valve, Link Motion, 7 examples—Expansion Valves and Gear, 10 examples—Details in General, 30 examples—Screw Propeller and Fittings, 13 examples Engine and Boiler Fittings, 28 examples – In relation to the Principles of the Marine Engine and Boiler, 33 examples.

Notices of the Press.

"Every conceivable detail of the Marine Engine, under all its various forms, is profusely, and we must add, admirably illustrated by a multitude of engravings, selected from the best and most modern practice of the first Marine Engineers of the day. The chapter on Condensers is peculiarly valuable. In one word, there is no other work in existence which will bear a moment's comparison with it as an exponent of the skill, talent and practical experience to which is due the splendid reputation enjoyed by many British Marine Engineers."—*Engineer.*

"This very comprehensive work, which was issued in Monthly parts, has just been completed. It contains large and full drawings and copious descriptions of most of the best examples of Modern Marine Engines, and it is a complete theoretical and practical treatise on the subject of Marine Engineering."—*American Artisan.*

This is the only edition of the above work with the beautifully *colored* plates, and it is out of print in England.

Bourne's Treatise on the Steam Engine.

Ninth Edition.

Illustrated. 4to. Cloth. $15.00.

TREATISE ON THE STEAM ENGINE in its various applications to Mines, Mills, Steam Navigation, Railways, and Agriculture, with the theoretical investigations respecting the Motive Power of Heat and the proper Proportions of Steam Engines. Elaborate Tables of the right dimensions of every part, and Practical Instructions for the Manufacture and Management of every species of Engine in actual use. By John Bourne, being the ninth edition of "A Treatise on the Steam Engine," by the "Artisan Club." Illustrated by thirty-eight plates and five hundred and forty-six wood-cuts.

As Mr. Bourne's work has the great merit of avoiding unsound and immature views, it may safely be consulted by all who are really desirous of acquiring trustworthy information on the subject of which it treats. During the twenty-two years which have elapsed from the issue of the first edition, the improvements introduced in the construction of the steam engine have been both numerous and important, and of these Mr. Bourne has taken care to point out the more prominent, and to furnish the reader with such information as shall enable him readily to judge of their relative value. This edition has been thoroughly modernized, and made to accord with the opinions and practice of the more successful engineers of the present day. All that the book professes to give is given with ability and evident care. The scientific principles which are permanent are admirably explained, and reference is made to many of the more valuable of the recently introduced engines. To express an opinion of the value and utility of such a work as *The Artisan Club's Treatise on the Steam Engine*, which has passed through eight editions already, would be superfluous; but it may be safely stated that the work is worthy the attentive study of all either engaged in the manufacture of steam engines or interested in economizing the use of steam.—*Mining Journal.*

Isherwood's Engineering Precedents.

Two Vols. in One. 8vo. Cloth. $2.50.

ENGINEERING PRECEDENTS FOR STEAM MACHINERY. Arranged in the most practical and useful manner for Engineers. By B. F. Isherwood, Civil Engineer, U. S. Navy. With illustrations.

Ward's Steam for the Million.

New and Revised Edition.

8vo. Cloth. $1.00.

STEAM FOR THE MILLION. A Popular Treatise on Steam and its Application to the Useful Arts, especially to Navigation. By J. H. WARD, Commander U. S. Navy. New and revised edition.

A most excellent work for the young engineer and general reader. Many facts relating to the management of the boiler and engine are set forth with a simplicity of language and perfection of detail that bring the subject home to the reader.—*American Engineer.*

Walker's Screw Propulsion.

8vo. Cloth. 75 cents.

NOTES ON SCREW PROPULSION, its Rise and History. By Capt. W. H. WALKER, U. S. Navy.

Commander Walker's book contains an immense amount of concise practical data, and every item of information recorded fully proves that the various points bearing upon it have been well considered previously to expressing an opinion.—*London Mining Journal.*

Page's Earth's Crust.

18mo. Cloth. 75 cents.

THE EARTH'S CRUST: a Handy Outline of Geology. By DAVID PAGE.

"Such a work as this was much wanted—a work giving in clear and intelligible outline the leading facts of the science, without amplification or irksome details. It is admirable in arrangement, and clear and easy, and, at the same time, forcible in style. It will lead, we hope, to the introduction of Geology into many schools that have neither time nor room for the study of large treatises."—*The Museum.*

Rogers' Geology of Pennsylvania.

3 Vols. 4to, with Portfolio of Maps. Cloth. $30.00.

THE GEOLOGY OF PENNSYLVANIA. A Government Survey. With a general view of the Geology of the United States, Essays on the Coal Formation and its Fossils, and a description of the Coal Fields of North America and Great Britain. By Henry Darwin Rogers, Late State Geologist of Pennsylvania. Splendidly illustrated with Plates and Engravings in the Text.

It certainly should be in every public library throughout the country, and likewise in the possession of all students of Geology. After the final sale of these copies, the work will, of course, become more valuable.

The work for the last five years has been entirely out of the market, but a few copies that remained in the hands of Prof. Rogers, in Scotland, at the time of his death, are now offered to the public, at a price which is even below what it was originally sold for when first published.

Elliot's European Light-Houses.

51 Engravings and 21 Wood-cuts. 8vo. Cloth. $5.00.

EUROPEAN LIGHT-HOUSE SYSTEMS. Being a Report of a Tour of Inspection made in 1873. By Major George H. Elliot, Corps of Engineers, U.S.A., member and Engineer Secretary of the Light-house Board.

Sweet's Report on Coal.

8vo. Cloth. $3.00.

SPECIAL REPORT ON COAL; showing its Distribution, Classification, and Cost delivered over different routes to various points in the State of New York, and the principal cities on the Atlantic Coast. By S. H. Sweet. With maps.

Colburn's Gas Works of London.

12mo. Boards. 60 cents.

GAS WORKS OF LONDON. By Zerah Colburn.

The Useful Metals and their Alloys; Scoffren, Truran, and others.

Fifth Edition.

8vo. Half calf. $3.75.

THE USEFUL METALS AND THEIR ALLOYS, including MINING VENTILATION, MINING JURISPRUDENCE AND METALLURGIC CHEMISTRY employed in the conversion of IRON, COPPER, TIN, ZINC, ANTIMONY, AND LEAD ORES, with their applications to THE INDUSTRIAL ARTS. By John Scoffren, William Truran, William Clay, Robert Oxland, William Fairbairn, W. C. Aitkin, and William Vose Pickett.

Collins' Useful Alloys.

18mo. Flexible. 75 cents.

THE PRIVATE BOOK OF USEFUL ALLOYS and Memoranda for Goldsmiths, Jewellers, etc. By James E. Collins

This little book is compiled from notes made by the Author from the papers of one of the largest and most eminent Manufacturing Goldsmiths and Jewellers in this country, and as the firm is now no longer in existence, and the Author is at present engaged in some other undertaking, he now offers to the public the benefit of his experience, and in so doing he begs to state that all the alloys, etc., given in these pages may be confidently relied on as being thoroughly practicable.

The Memoranda and Receipts throughout this book are also compiled from practice, and will no doubt be found useful to the practical jeweller. —*Shirley, July*, 1871.

Joynson's Metals Used in Construction.

12mo. Cloth. 75 cents.

THE METALS USED IN CONSTRUCTION: Iron, Steel, Bessemer Metal, etc., etc. By Francis Herbert Joynson. Illustrated.

"In the interests of practical science, we are bound to notice this work; and to those who wish further information, we should say, buy it; and the outlay, we honestly believe, will be considered well spent." —*Scientific Review.*

Prescott's Proximate Organic Analysis.

12mo. Cloth. $1.75.

OUTLINES OF PROXIMATE ORGANIC ANALYSIS for the Identification, Separation, and Quantitative Determination of the more commonly occurring Organic Compounds. By ALBERT B. PRESCOTT, Professor of Organic and Applied Chemistry in the University of Michigan.

Prescott's Alcoholic Liquors.

12mo. Cloth. $1.50.

CHEMICAL EXAMINATION OF ALCOHOLIC LIQUORS. A Manual of the Constituents of the Distilled Spirits and Fermented Liquors of Commerce, and their Qualitative and Quantitative Determinations. By ALBERT B. PRESCOTT, Professor of Organic and Applied Chemistry in the University of Michigan.

Greene's Bridge Trusses.

8vo. Illustrated. Cloth. $2.00.

GRAPHICAL METHOD FOR THE ANALYSIS OF BRIDGE TRUSSES, extended to Continuous Girders and Draw Spans. By CHARLES E. GREENE, A.M., Professor of Civil Engineering, University of Michigan. Illustrated by three folding plates.

Butler's Projectiles and Rifled Cannon.

4to. 36 Plates. Cloth. $7.50.

PROJECTILES AND RIFLED CANNON. A Critical Discussion of the Principal Systems of Rifling and Projectiles, with Practical Suggestions for their Improvement, as embraced in a Report to the Chief of Ordnance, U.S.A. By Capt. JOHN S. BUTLER, Ordnance Corps, U.S.A.

Peirce's Analytic Mechanics.

4to. Cloth. $10.00.

SYSTEM OF ANALYTIC MECHANICS. By BENJAMIN PEIRCE, Perkins Professor of Astronomy and Mathematics in Harvard University, and Consulting Astronomer of the American Ephemeris and Nautical Almanac.

"I have re-examined the memoirs of the great geometers, and have striven to consolidate their latest researches and their most exalted forms of thought into a consistent and uniform treatise. If I have hereby succeeded in opening to the students of my country a readier access to these choice jewels of intellect; if their brilliancy is not impaired in this attempt to reset them; if, in their own constellation, they illustrate each other, and concentrate a stronger light upon the names of their discoverers, and, still more, if any gem which I may have presumed to add is not wholly lustreless in the collection, I shall feel that my work has not been in vain."—*Extract from the Preface.*

Burt's Key to Solar Compass.

Second Edition.

Pocket Book Form. Tuck. $2.50.

KEY TO THE SOLAR COMPASS, and Surveyor's Companion; comprising all the Rules necessary for use in the field; also, Description of the Linear Surveys and Public Land System of the United States, Notes on the Barometer, Suggestions for an outfit for a Survey of four months, etc., etc., etc. By W. A. BURT, U. S. Deputy Surveyor. Second edition.

Chauvenet's Lunar Distances.

8vo. Cloth. $2.00.

NEW METHOD OF CORRECTING LUNAR DISTANCES, and Improved Method of Finding the Error and Rate of a Chronometer, by equal altitudes. By WM. CHAUVENET, LL.D., Chancellor of Washington University of St. Louis.

Jeffers' Nautical Surveying.

Illustrated with 9 Copperplates and 31 Wood-cut Illustrations. 8vo. Cloth. $5.00.

NAUTICAL SURVEYING. By WILLIAM N. JEFFERS, Captain U. S. Navy.

Many books have been written on each of the subjects treated of in the sixteen chapters of this work; and, to obtain a complete knowledge of geodetic surveying requires a profound study of the whole range of mathematical and physical sciences; but a year of preparation should render any intelligent officer competent to conduct a nautical survey.

CONTENTS.—Chapter I. Formulæ and Constants Useful in Surveying II. Distinctive Character of Surveys. III. Hydrographic Surveying under Sail; or, Running Survey. IV. Hydrographic Surveying of Boats; or, Harbor Survey. V. Tides—Definition of Tidal Phenomena—Tidal Observations. VI. Measurement of Bases—Appropriate and Direct. VII. Measurement of the Angles of Triangles—Azimuths—Astronomical Bearings. VIII. Corrections to be Applied to the Observed Angles. IX. Levelling—Difference of Level. X. Computation of the Sides of the Triangulation—The Three-point Problem. XI. Determination of the Geodetic Latitudes, Longitudes, and Azimuths, of Points of a Triangulation. XII. Summary of Subjects treated of in preceding Chapters—Examples of Computation by various Formulæ. XIII. Projection of Charts and Plans. XIV. Astronomical Determination of Latitude and Longitude. XV. Magnetic Observations. XVI. Deep Sea Soundings. XVII. Tables for Ascertaining Distances at Sea, and a full Index.

List of Plates.

Plate I. Diagram Illustrative of the Triangulation. II. Specimen Page of Field Book. III. Running Survey of a Coast. IV. Example of a Running Survey from Belcher. V. Flying Survey of an Island. VI. Survey of a Shoal. VII. Boat Survey of a River. VIII. Three-Point Problem. IX. Triangulation.

Coffin's Navigation.

Fifth Edition.

12mo. Cloth. $3.50.

NAVIGATION AND NAUTICAL ASTRONOMY. Prepared for the use of the U. S. Naval Academy. By J. H. C. COFFIN, Prof. of Astronomy, Navigation and Surveying, with 52 woodcut illustrations.

Clark's Theoretical Navigation.

8vo. Cloth. $3.00.

THEORETICAL NAVIGATION AND NAUTICAL ASTRONOMY. By Lewis Clark, Lieut.-Commander, U. S. Navy. Illustrated with 41 Wood-cuts, including the Vernier.

Prepared for Use at the U. S. Naval Academy.

The Plane Table.

Illustrated. 8vo. Cloth. $2.00.

ITS USES IN TOPOGRAPHICAL SURVEYING. From the Papers of the U. S. Coast Survey.

This work gives a description of the Plane Table employed at the U. S. Coast Survey Office, and the manner of using it.

Book on Shipbuilding.

8vo. Cloth. $5.00.

METHOD OF COMPARING THE LINES AND DRAUGHTING VESSELS PROPELLED BY SAIL OR STEAM, including a Chapter on Laying off on the Mould-Loft Floor. By Samuel M. Pook, Naval Constructor. 1 vol., 8vo. With illustrations. Cloth. $5.00.

Brunnow's Spherical Astronomy.

8vo. Cloth. $6.50.

SPHERICAL ASTRONOMY. By F. Brunnow, Ph. Dr. Translated by the Author from the Second German edition.

Van Buren's Formulas.

8vo. Cloth. $2.00.

INVESTIGATIONS OF FORMULAS, for the Strength of the Iron Parts of Steam Machinery. By J. D. Van Buren, Jr., C. E. Illustrated.

This is an analytical discussion of the formulæ employed by mechanical engineers in determining the rupturing or crippling pressure in the different parts of a machine. The formulæ are founded upon the principle, that the different parts of a machine should be equally strong, and are developed in reference to the ultimate strength of the material in order to leave the choice of a factor of safety to the judgment of the designer. —*Silliman's Journal.*

Joynson on Machine Gearing.

8vo. Cloth. $2.00.

THE MECHANIC'S AND STUDENT'S GUIDE in the Designing and Construction of General Machine Gearing, as Eccentrics, Screws, Toothed Wheels, etc., and the Drawing of Rectilineal and Curved Surfaces; with Practical Rules and Details. Edited by Francis Herbert Joynson. Illustrated with 18 folded plates.

"The aim of this work is to be a guide to mechanics in the designing and construction of general machine-gearing. This design it well fulfils, being plainly and sensibly written, and profusely illustrated."—*Sunday Times.*

Barnard's Report, Paris Exposition, 1867.

Illustrated. 8vo. Cloth. $5.00.

REPORT ON MACHINERY AND PROCESSES ON THE INDUSTRIAL ARTS AND APPARATUS OF THE EXACT SCIENCES. By F. A. P. Barnard, LL.D.—Paris Universal Exposition, 1867.

"We have in this volume the results of Dr. Barnard's study of the Paris Exposition of 1867, in the form of an official Report of the Government. It is the most exhaustive treatise upon modern inventions that has appeared since the Universal Exhibition of 1851, and we doubt if anything equal to it has appeared this century."—*Journal Applied Chemistry.*

Engineering Facts and Figures.

18mo. Cloth. $2.50 per Volume.

AN ANNUAL REGISTER OF PROGRESS IN MECHANICAL ENGINEERING AND CONSTRUCTION, for the Years 1863–64–65–66–67–68. Fully illustrated. 6 volumes.

Each volume sold separately.

Beckwith's Pottery.

8vo. Paper. 60 cents.

OBSERVATIONS ON THE MATERIALS and Manufacture of Terra-Cotta, Stone-Ware, Fire-Brick, Porcelain and Encaustic Tiles, with Remarks on the Products exhibited at the London International Exhibition, 1871. By ARTHUR BECKWITH, Civil Engineer.

"Everything is noticed in this book which comes under the head of Pottery, from fine porcelain to ordinary brick, and aside from the interest which all take in such manufactures, the work will be of considerable value to followers of the ceramic art."—*Evening Mail.*

Dodd's Dictionary of Manufactures, etc.

12mo. Cloth. $2.00.

DICTIONARY OF MANUFACTURES, MINING, MACHINERY, AND THE INDUSTRIAL ARTS. By GEORGE DODD.

This work, a small book on a great subject, treats, in alphabetical arrangement, of those numerous matters which come generally within the range of manufactures and the productive arts. The raw materials—animal, vegetable, and mineral—whence the manufactured products are derived, are succinctly noticed in connection with the processes which they undergo, but not as subjects of natural history. The operations of the Mine and the Mill, the Foundry and the Forge, the Factory and the Workshop, are passed under review. The principal machines and engines, tools and apparatus, concerned in manufacturing processes, are briefly described. The scale on which our chief branches of national industry are conducted, in regard to values and quantities, is indicated in various ways.

Stuart's Civil and Military Engineering of America.

8vo. Illustrated. Cloth. $5.00.

THE CIVIL AND MILITARY ENGINEERS OF AMERICA. By General Charles B. Stuart, Author of "Naval Dry Docks of the United States," etc., etc. Embellished with nine finely executed portraits on steel of eminent engineers, and illustrated by engravings of some of the most important and original works constructed in America.

Containing sketches of the Life and Works of Major Andrew Ellicott, James Geddes (with Portrait), Benjamin Wright (with Portrait), Canvass White (with Portrait), David Stanhope Bates, Nathan S. Roberts, Gridley Bryant (with Portrait), General Joseph G. Swift, Jesse L. Williams (with Portrait), Colonel William McRee, Samuel H. Kneass, Captain John Childe with Portrait), Frederick Harbach, Major David Bates Douglas (with Portrait), Jonathan Knight, Benjamin H. Latrobe (with Portrait), Colonel Charles Ellet, Jr. (with Portrait), Samuel Forrer, William Stuart Watson, John A. Roebling.

Alexander's Dictionary of Weights and Measures.

8vo. Cloth. $3.50.

UNIVERSAL DICTIONARY OF WEIGHTS AND MEASURES, Ancient and Modern, reduced to the standards of the United States of America. By J. H. Alexander. New edition. 1 vol.

"As a standard work of reference, this book should be in every library; it is one which we have long wanted, and it will save much trouble and research."—*Scientific American.*

Blake's Ceramic Art.

8vo. Cloth. $2.00.

A REPORT ON POTTERY, PORCELAIN, TILES, TERRA-COTTA, AND BRICK. By William P. Blake, United States Commissioner Internal Exhibition at Vienna, 1873.

Saeltzer's Acoustics.

12mo. Cloth. $2.00.

TREATISE ON ACOUSTICS in Connection with Ventilation. With a new theory based on an important discovery, of facilitating clear and intelligible sound in any building. By Alexander Saeltzer.

"A practical and very sound treatise on a subject of great importance to architects, and one to which there has hitherto been entirly too little attention paid. The author's theory is, that, by bestowing proper care upon the point of Acoustics, the requisite ventilation will be obtained, and *vice versa.*—*Brooklyn Union.*

Myer's Manual of Signals.

New Edition. Enlarged.

12mo. 48 Plates full Roan. $5.00.

MANUAL OF SIGNALS, for the Use of Signal Officers in the Field, and for Military and Naval Students, Military Schools, etc. A new edition, enlarged and illustrated. By Brig.-Gen. Albert J. Myer, Chief Signal Officer of the Army, Colonel of the Signal Corps during the War of the Rebellion.

Larrabee's Secret Letter and Telegraph Code.

18mo. Cloth. $1.00.

CIPHER AND SECRET LETTER AND TELEGRAPHIC CODE, with Hogg's Improvements. The most perfect secret Code ever invented or discovered. Impossible to read without the Key. Invaluable for Secret, Military, Naval, and Diplomatic Service, as well as for Brokers, Bankers, and Merchants. By C. S. Larrabee, the original inventor of the scheme.

Rice & Johnson's Differential Functions.

12mo. Cloth.

ON A NEW METHOD OF OBTAINING THE DIFFERENTIALS OF FUNCTIONS, with especial reference to the Newtonian Conception of Rates or Velocities. By J. MINOT RICE, Prof. of Mathematics in the U. S. Navy, and W. WOOLSEY JOHNSON, Prof. of Mathematics in St. John's College, Annapolis.

Pickert and Metcalf's Art of Graining.

1 vol. 4to. Cloth. $10.00.

THE ART OF GRAINING. How Acquired and How Produced, with description of colors and their application. By CHARLES PICKERT and ABRAHAM METCALF. Beautifully illustrated with 42 tinted plates of the various woods used in interior finishing. Tinted paper.

The authors present here the result of long experience in the practice of this decorative art, and feel confident that they hereby offer to their brother artisans a reliable guide to improvement in the practice of graining.

Porter's Steam-Engine Indicator.

Third Edition. Revised and Enlarged. 8vo. Illustrated. Cloth. $3.50.

A TREATISE ON THE RICHARDS STEAM-ENGINE INDICATOR, and the Development and Application of Force in the Steam-Engine. By CHARLES T. PORTER.

One Law in Nature.

12mo. Cloth. $1.50.

ONE LAW IN NATURE. By Capt. H. M. LAZELLE, U. S. A. A New Corpuscular Theory, comprehending Unity of Force, Identity of Matter, and its Multiple Atom Constitution, applied to the Physical Affections or Modes of Energy.

Ernst's Manual of Military Engineering.

193 Wood Cuts and 8 Lithographed Plates. 12mo. Cloth. $5.00.

A MANUAL OF PRACTICAL MILITARY ENGINEERING. Prepared for the use of the Cadets of the U. S. Military Academy, and for Engineer Troops. By Capt. O. H. ERNST, Corps of Engineers, Instructor in Practical Military Engineering, U. S. Military Academy.

Church's Metallurgical Journey.

24 Illustrations. 8vo. Cloth. $2.00.

NOTES OF A METALLURGICAL JOURNEY IN EUROPE. By JOHN A. CHURCH, Engineer of Mines.

Blake's Precious Metals.

8vo. Cloth. $2.00.

REPORT UPON THE PRECIOUS METALS: Being Statistical Notices of the principal Gold and Silver producing regions of the World. Represented at the Paris Universal Exposition. By WILLIAM P. BLAKE, Commissioner from the State of California.

Clevenger's Surveying.

Illustrated Pocket Form. Morocco Gilt. $2.50.

A TREATISE ON THE METHOD OF GOVERNMENT SURVEYING, as prescribed by the United States Congress. and Commissioner of the General Land Office. With complete Mathematical, Astronomical and Practical Instructions, for the use of the United States Surveyors in the Field, and Students who contemplate engaging in the business of Public Land Surveying. By S. R. CLEVENGER, U. S. Deputy Surveyor.

"The reputation of the author as a surveyor guarantees an exhaustive treatise on this subject."—*Dakota Register.*

"Surveyors have long needed a text-book of this description.—*The Press.*

Bow on Bracing.

156 Illustrations on Stone. 8vo. Cloth. $1.50.

A TREATISE ON BRACING, with its application to Bridges and other Structures of Wood or Iron. By ROBERT HENRY BOW, C. E.

Howard's Earthwork Mensuration.

8vo. Illustrated. Cloth. $1.50.

EARTHWORK MENSURATION ON THE BASIS OF THE PRISMOIDAL FORMULÆ. Containing simple and labor-saving method of obtaining Prismoidal Contents directly from End Areas. Illustrated by Examples, and accompanied by Plain Rules for practical uses. By CONWAY R. HOWARD, Civil Engineer, Richmond, Va.

"Major Howard has given in this book a simple, yet perfectly accurate method of ascertaining the solid contents of any prismoid. The calculation from end areas is corrected by tables well arranged and few in number ; and he has all the accuracy of the prismoidal formulæ with scarcely more trouble than in averaging end areas.

H. D. WHITCOMB,
Chief Engineer Chesapeake and Ohio R. R.
E. T. D. MYERS,
Chief Engineer Richmond, Fredericksburg, and Potomac R. R."

Mowbray's Tri-Nitro-Glycerine.

8vo. Cloth. Illustrated. $3.00.

TRI-NITRO-GLYCERINE, as applied in the Hoosac Tunnel, and to Submarine Blasting, Torpedoes, Quarrying, etc. Being the result of six years' observation and practice during the manufacture of five hundred thousand pounds of this explosive, Mica Blasting Powder, Dynamites; with an account of the various Systems of Blasting by Electricity, Priming Compounds, Explosives, etc., etc. By George M. Mowbray, Operative Chemist, with thirteen illustrations, tables, and appendix. Third Edition. Re-written.

Wanklyn's Milk Analysis.

12mo. Cloth. $1.00.

MILK ANALYSIS. A Practical Treatise on the Examination of Milk, and its Derivatives, Cream, Butter and Cheese. By J. Alfred Wanklyn, M. R. C. S.

Toner's Dictionary of Elevations.

8vo. Paper, $3.00. Cloth, $3.75.

DICTIONARY OF ELEVATIONS AND CLIMATIC REGISTER OF THE UNITED STATES. Containing, in addition to Elevations, the Latitude, Mean Annual Temperature, and the total Annual Rain Fall of many localities; with a brief Introduction on the Orographic and Physical Peculiarities of North America. By J. M. Toner, M. D.

Adams. Sewers and Drains.

(*In Press.*)

SEWERS AND DRAINS FOR POPULOUS DISTRICTS. Embracing Rules and Formulas for the dimensions and construction of works of Sanitary Engineers. By Julius W. Adams, Chief Engineer of the Board of City Works, Brooklyn.

SILVER MINING REGIONS OF COLORADO, with some account of the different Processes now being introduced for working the Gold Ores of that Territory. By J. P. WHITNEY. 12mo. Paper. 25 cents.

COLORADO: SCHEDULE OF ORES contributed by sundry persons to the Paris Universal Exposition of 1867, with some information about the Region and its Resources. By J. P. WHITNEY, Commissioner from the Territory. 8vo. Paper, with Maps. 25 cents.

THE SILVER DISTRICTS OF NEVADA. With Map. 8vo. Paper. 35 cents.

ARIZONA: ITS RESOURCES AND PROSPECTS. By Hon. R. C. MCCORMICK, Secretary of the Territory. With Map. 8vo. Paper. 25 cents.

MONTANA AS IT IS. Being a general description of its Resources, both Mineral and Agricultural; including a complete description of the face of the country, its climate, etc. Illustrated with a Map of the Territory, showing the different Roads and the location of the different Mining Districts. To which is appended a complete Dictionary of THE SNAKE LANGUAGE, and also of the famous Chinnook Jargon, with numerous critical and explanatory Notes. By GRANVILLE STUART. 8vo. Paper. $2.00.

RAILWAY GAUGES. A Review of the Theory of Narrow Gauges as applied to Main Trunk Lines of Railway. By SILAS SEYMOUR, Genl. Consulting Engineer. 8vo. Paper. 50 cents.

REPORT made to the President and Executive Board of the Texas Pacific Railroad. By Gen. G. P. BUELL, Chief Engineer. 8vo. Paper. 75 cents.

Van Nostrand's Science Series.

It is the intention of the Publisher of this Series to issue them at intervals of about a month. They will be put up in a uniform, neat and attractive form, 18mo, fancy boards. The subjects will be of an eminently scientific character, and embrace as wide a range of topics as possible, all of the highest character.

Price, 50 Cents Each.

1.

CHIMNEYS FOR FURNACES, FIRE-PLACES, AND STEAM BOILERS. By R. Armstrong, C. E.

2.

STEAM BOILER EXPLOSIONS. By Zerah Colburn.

3.

PRACTICAL DESIGNING OF RETAINING WALLS By Arthur Jacob, A. B. With Illustrations.

4.

PROPORTIONS OF PINS USED IN BRIDGES. By Charles E. Bender, C. E. With Illustrations.

5.

VENTILATION OF BUILDINGS. By W. F. Butler. With Illustrations.

6.

ON THE DESIGNING AND CONSTRUCTION OF STORAGE RESERVOIRS. By Arthur Jacob. With Illustrations.

7.

SURCHARGED AND DIFFERENT FORMS OF RETAINING WALLS. By James S. Tate, C. E.

8.

A TREATISE ON THE COMPOUND ENGINE. By John Turnbull. With Illustrations.

9.

FUEL. By C. William Siemens, to which is appended the value of ARTIFICIAL FUELS AS COMPARED WITH COAL. By John Wormald, C. E.

10.

COMPOUND ENGINES. Translated from the French of A. Mallet. Illustrated.

11.

THEORY OF ARCHES. By Prof. W. ALLAN, of the Washington and Lee College. Illustrated.

12.

A PRACTICAL THEORY OF VOUSSOIR ARCHES. By WILLIAM CAIN, C.E. Illustrated.

13.

A PRACTICAL TREATISE ON THE GASES MET WITH IN COAL-MINES. By the late J. J. ATKINSON, Government Inspector of Mines for the County of Durham, England.

14.

FRICTION OF AIR IN MINES. By J. J. ATKINSON, author of "A Practical Treatise on the Gases met with in Coal-Mines."

15.

SKEW ARCHES. By Prof. E. W. HYDE, C.E. Illustrated with numerous engravings and three folded plates.

16.

A GRAPHIC METHOD FOR SOLVING CERTAIN ALGEBRAIC EQUATIONS. By Prof. GEORGE L. VOSE. With illustrations.

17.

WATER AND WATER SUPPLY. By Prof. W. H. CORFIELD, M.A., of the University College, London.

18.

SEWERAGE AND SEWAGE UTILIZATION. By Prof. W. H. CORFIELD, M.A., of the University College, London.

19.

STRENGTH OF BEAMS UNDER TRANSVERSE LOADS. By Prof. W. ALLAN, author of "Theory of Arches." With illustrations.

20.

BRIDGE AND TUNNEL CENTRES. By JOHN B. MCMASTERS, C. E. With illustrations.

The Rebellion Record.

EDITED BY FRANK MOORE.

Complete in 12 Volumes.

With 158 Steel Engraved Portraits of Distinguished Generals and Prominent Men; together with numerous Maps and Plans of Battles.

THE REBELLION RECORD. Containing a full and concise Diary of Events, from the meeting of the South Carolina Convention in December, 1860, to the close of the War of the Rebellion, together with Official Reports of both Federal and Confederate State Officers, and Narratives of all the Battles and Skirmishes that occurred. 12 vols., cloth, $60.00; library sheep, $72.00; half calf, antique, $78.00; half morocco, $78.00; half russia, $84.00.

*** Single volumes to complete sets furnished at the same rates.

There are very few men of ordinary intelligence, and possessing an ordinary share of interest in the war which for a long period so entirely engrossed the public attention, who have not very often desired to fix the date of some important battle, some change of commanders, or the issue of some noteworthy proclamation. There are fewer still who would not feel an interest in recurring to the vivid description of some important engagement by sea or land, in which mayhap a kinsman or friend participated.

The Rebellion Record has, as we believe, a claim to a very wide circulation on the following grounds: its accuracy, its impartiality, its completeness, its preservation of all the materials for a future history of the struggle, its connected diary, its valuable documents, its interesting collection of incidents, its garnering up the poetry called out by the war, and its unique character, as the only work of its kind.

The Rebellion Record has now become so firmly established as the standard authority of the war, that individuals in all departments of the Army, Navy, and Government, are constantly referring to it, for narratives of important events, and official reports unpublished elsewhere.

This work is a compendium of information, made up of special correspondence, official reports, and gleanings from the newspapers of both sections of the United States and of Europe. Of these latter, over five hundred are used in its preparation.

RETURN TO the circulation desk of any
University of California Library
or to the
NORTHERN REGIONAL LIBRARY FACILITY
Bldg. 400, Richmond Field Station
University of California
Richmond, CA 94804-4698

ALL BOOKS MAY BE RECALLED AFTER 7 DAYS
- 2-month loans may be renewed by calling (510) 642-6753
- 1-year loans may be recharged by bringing books to NRLF
- Renewals and recharges may be made 4 days prior to due date.

DUE AS STAMPED BELOW

APR 14 1997

12,000 (11/95)